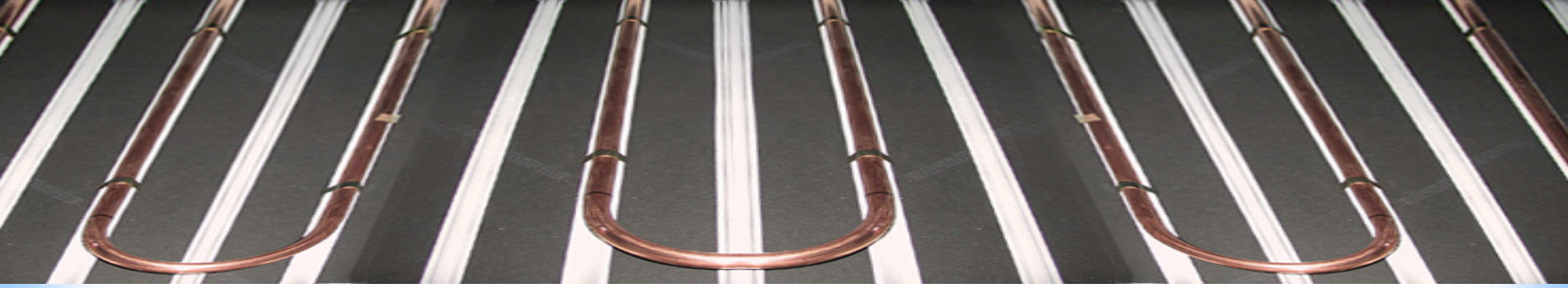
HYDRONIC RADIANT CEILINGS and CHILLED BEAMS

Low Mass

Heating and Cooling

Learning Objectives

- How does radiant heating and cooling work how does low mass differ from high?
- What are hydronic radiant panels?
- What are chilled beams?
- How do panels/beams fit in a project, what do they look like?
- What are the economics and LEED impact of panel/beam systems?
- What does DOE say about radiant panels?
- How are radiant panels installed?



Hydronic Radiant Ceilings

- **Panels constructed of steel or aluminum.**
- **Copper tubing attached to the panel to allow for differing expansion rates.**
- **Panels available in different styles to accommodate ceiling applications**

Hydronic Radiant Ceilings

Heating

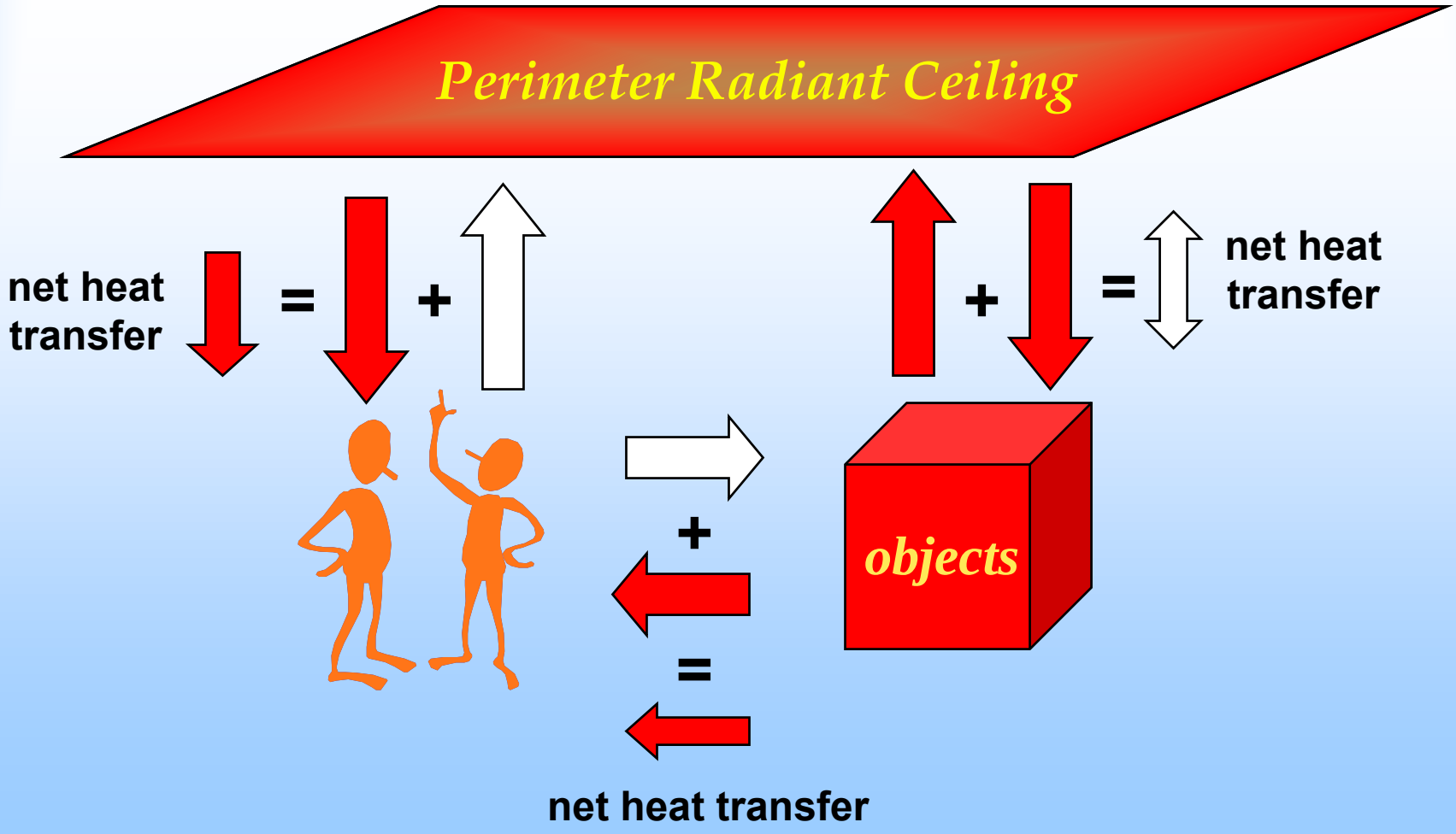
- Generally located along perimeters
  - Effect all exposed areas (line of sight).
- Uses less than 25% of ceiling area
  - Can use elevated water temperatures.
- Are not effected by floor coverings
  - carpets, pads, multilayer floors

Hydronic Radiant Ceilings

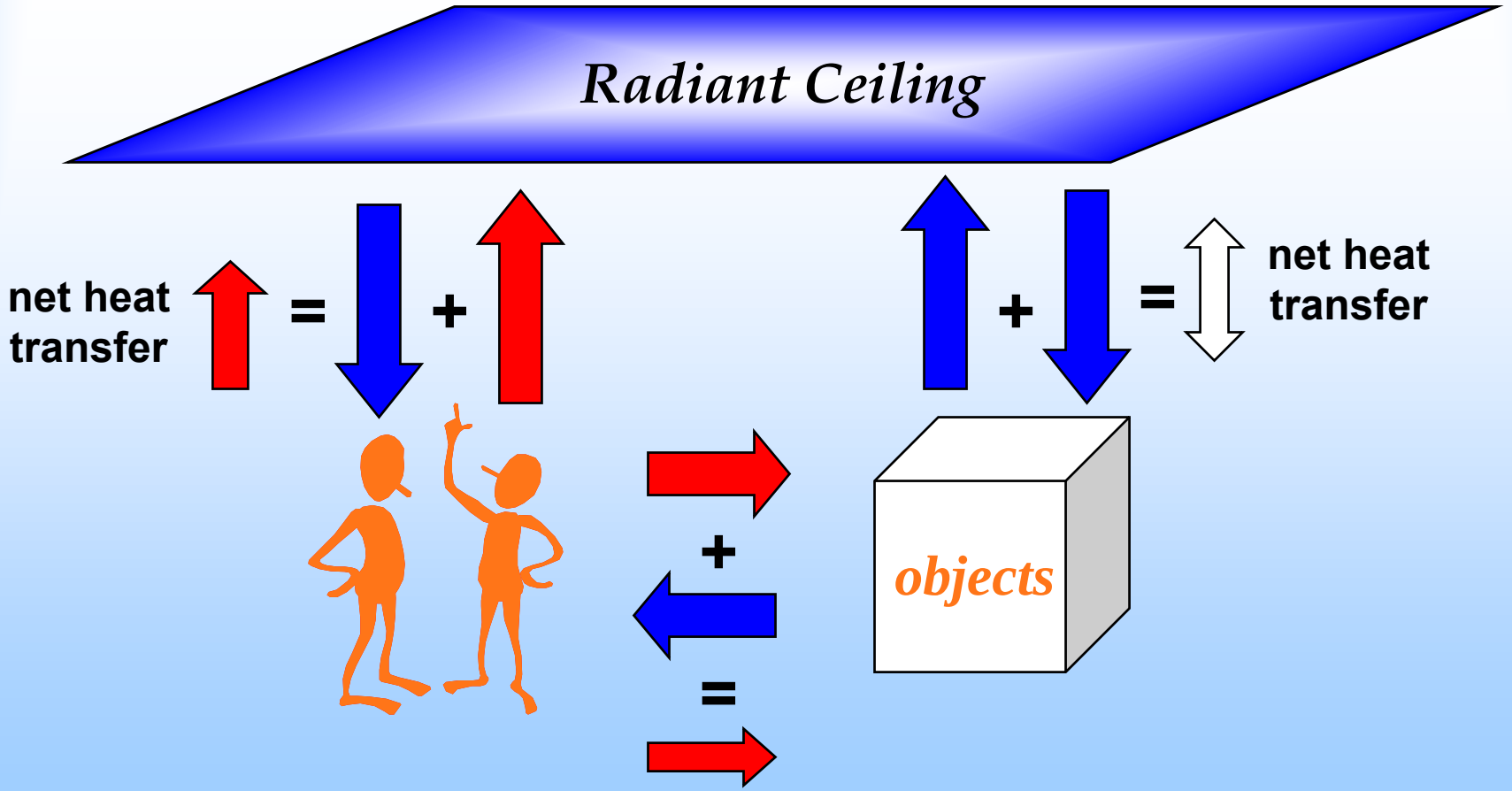
Cooling

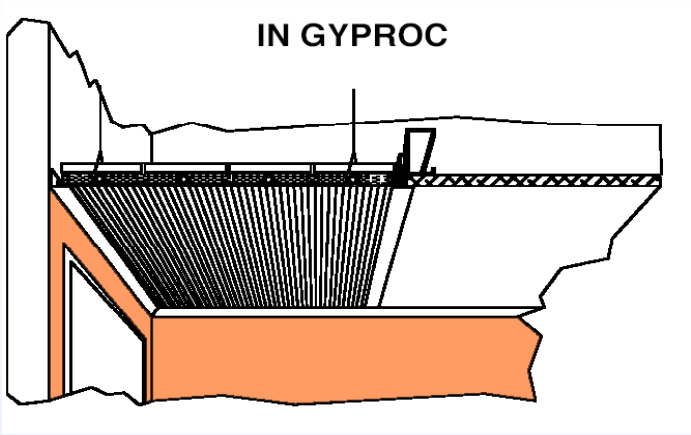
- Generally require 50% of ceiling area
  - Smaller operating ΔT
- Use chilled water temperatures above dew point.
- Designed for sensible loads only
  - Remove moisture in makeup air
  - Low mass panels can react quickly

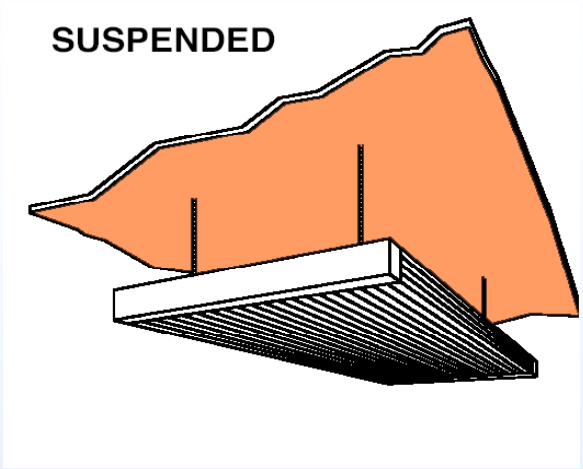
Radiant Heating Effect

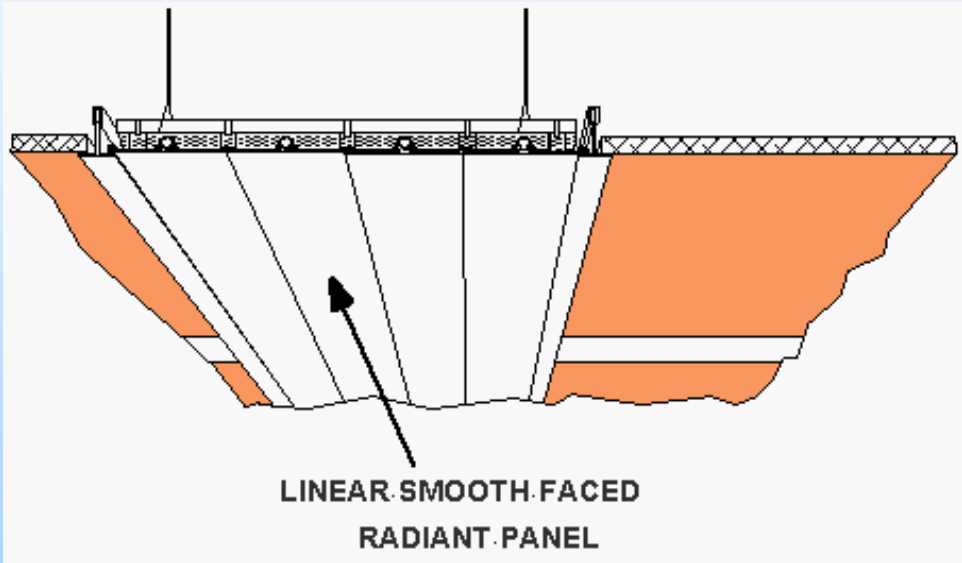


Radiant Cooling Effect

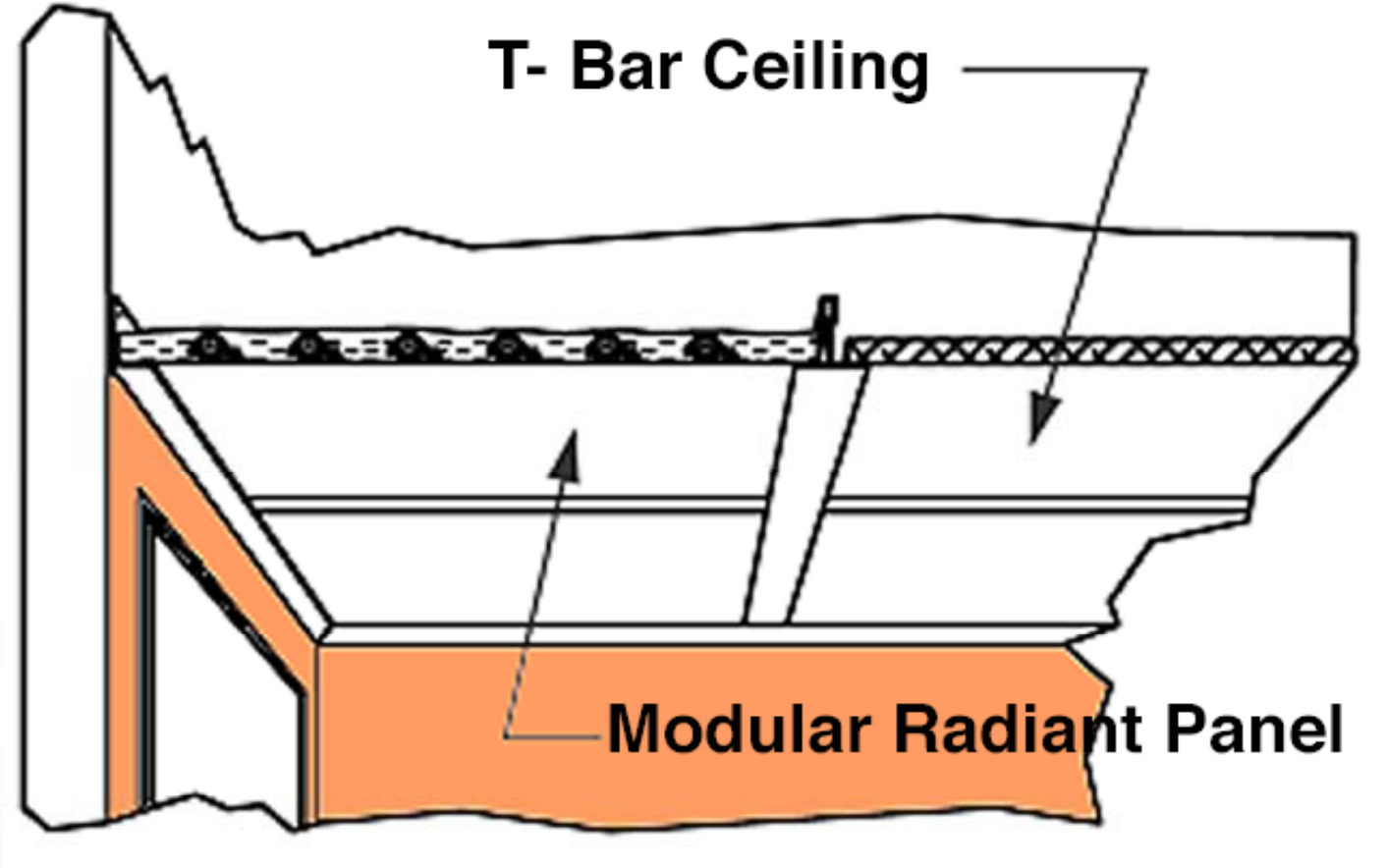






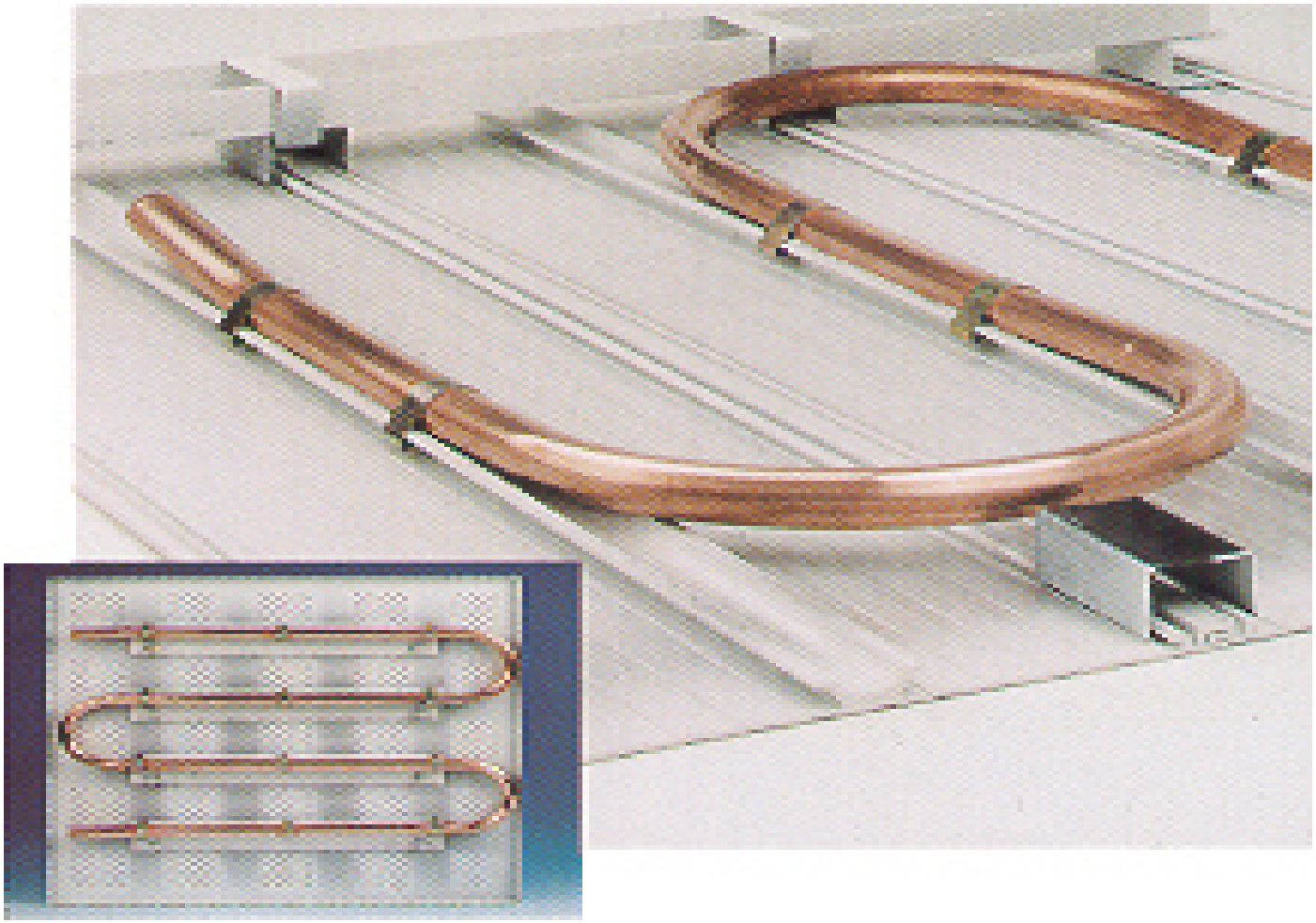


Linear Radiant Panels

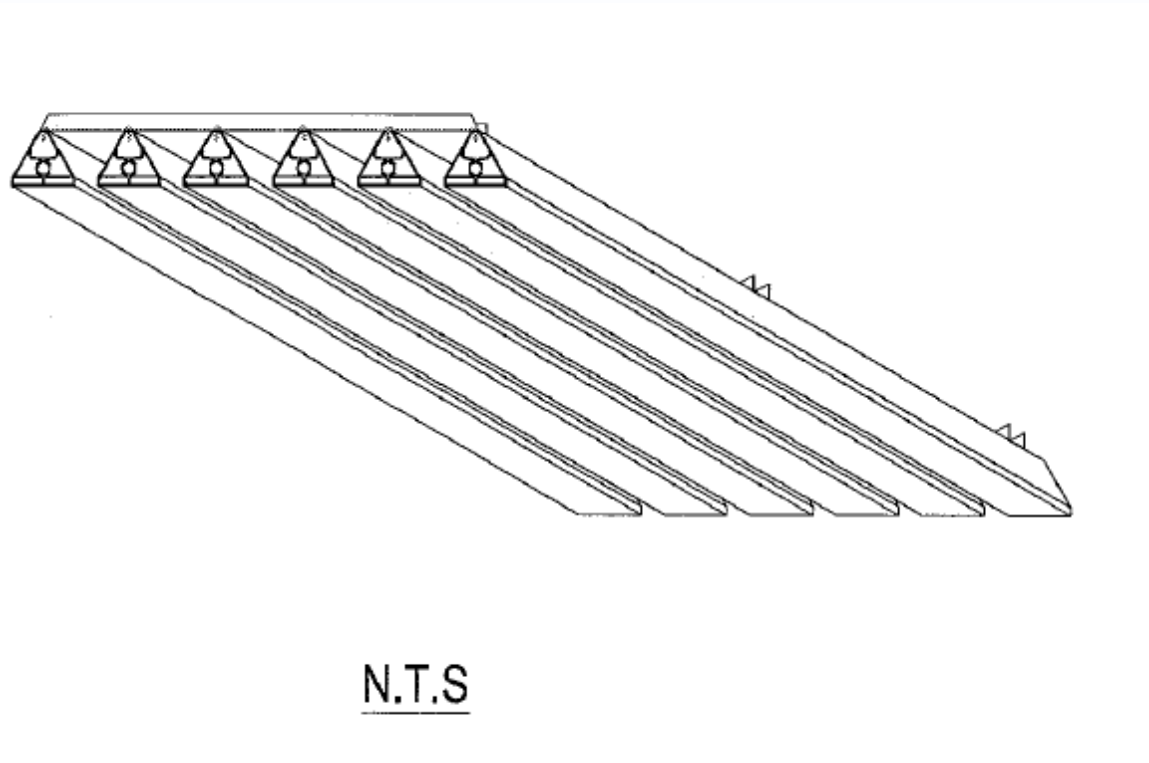


Modular Radiant Panels

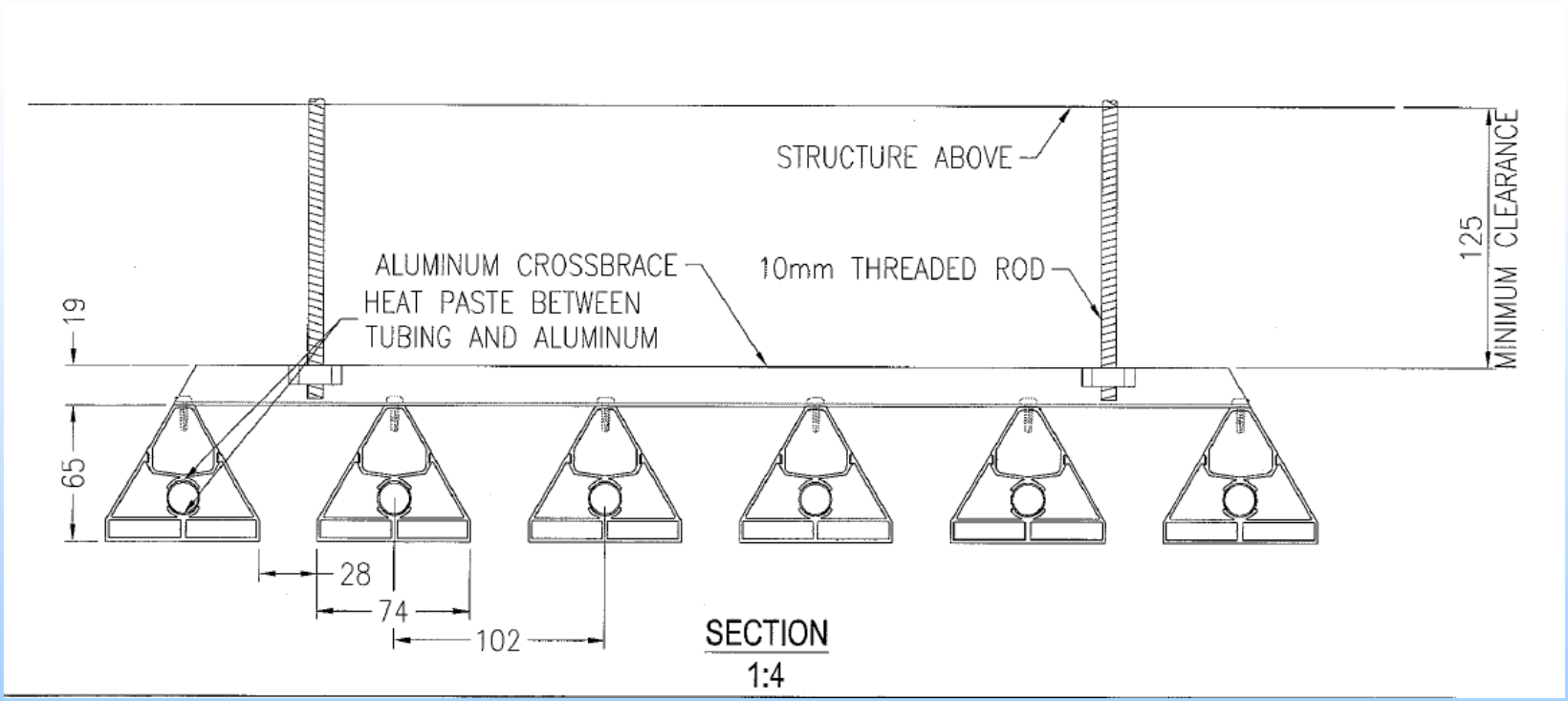
Back view of Modular and Linear Panels



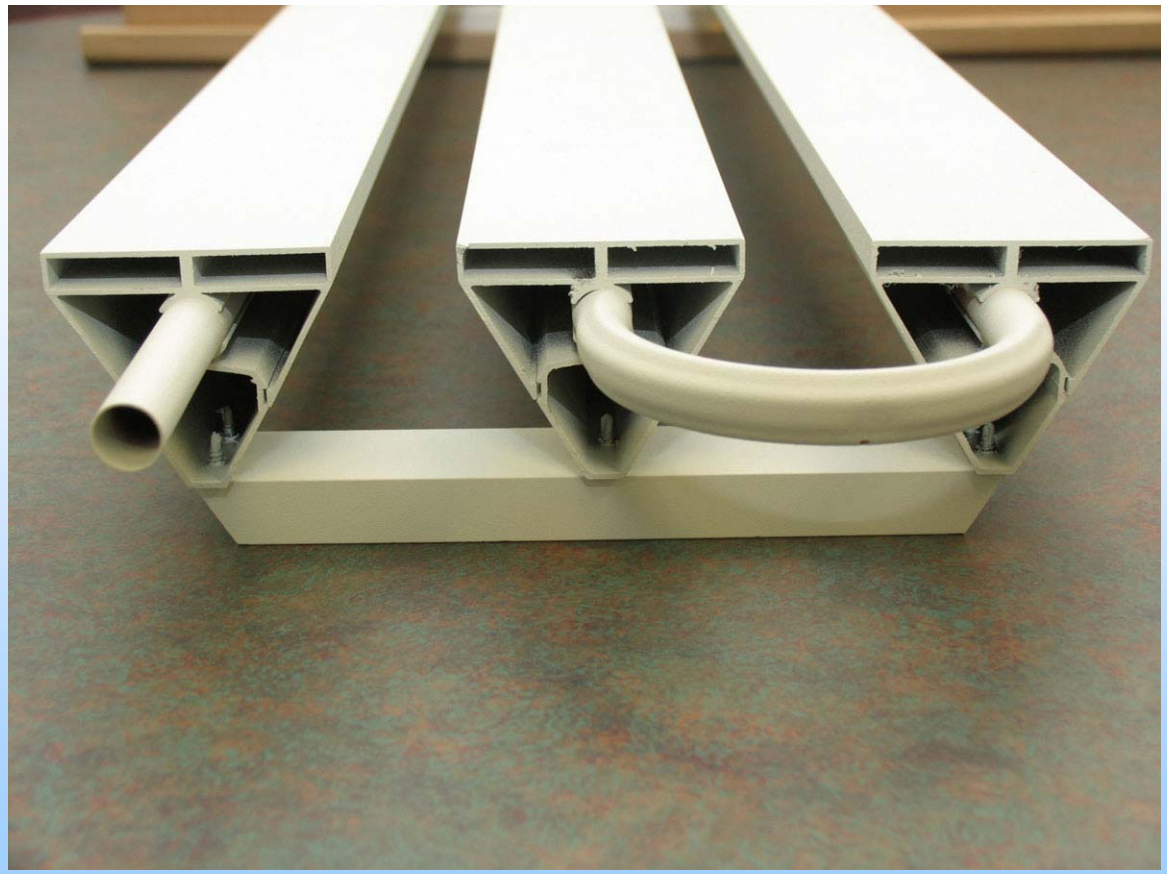
Tri-Base Sail 6 Tube



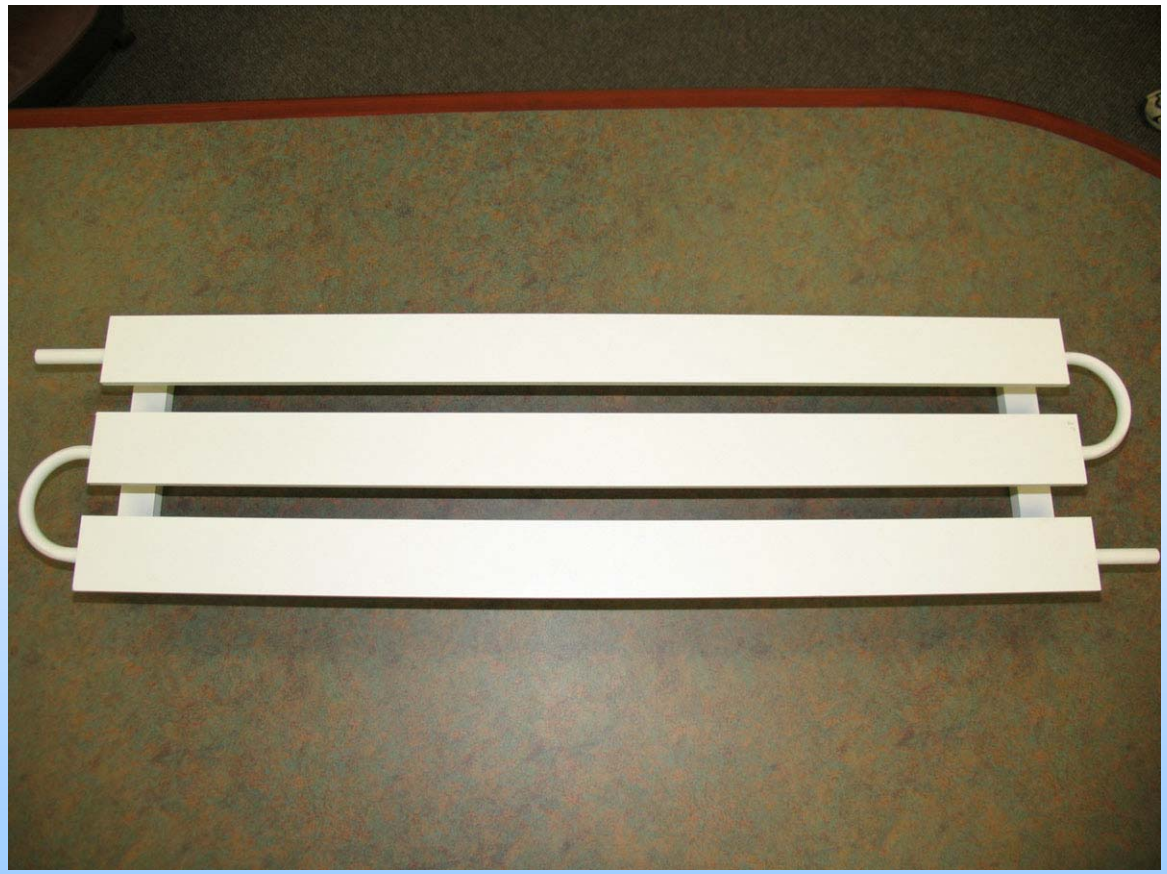
Tri-Base Sail Mounting



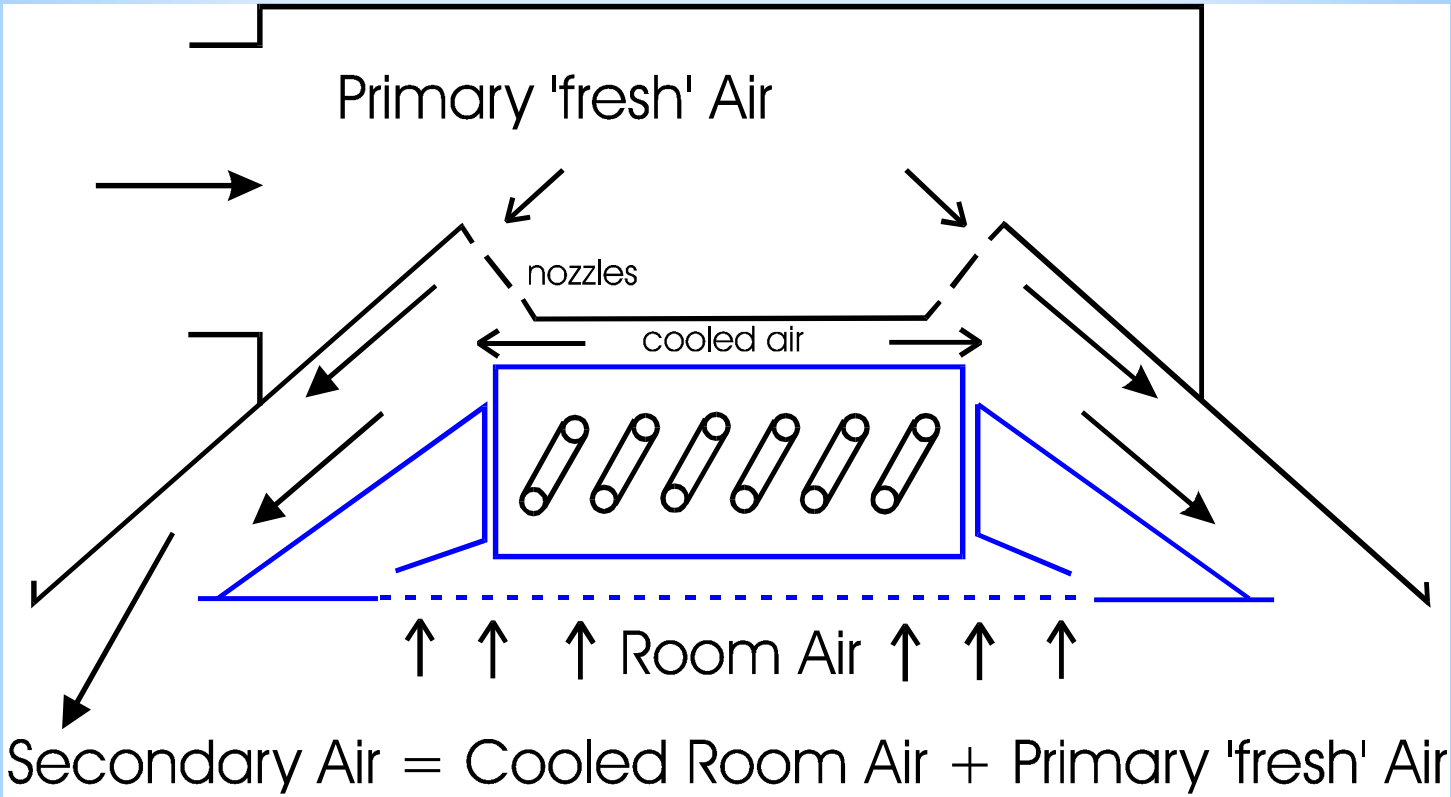
Radiant Sail



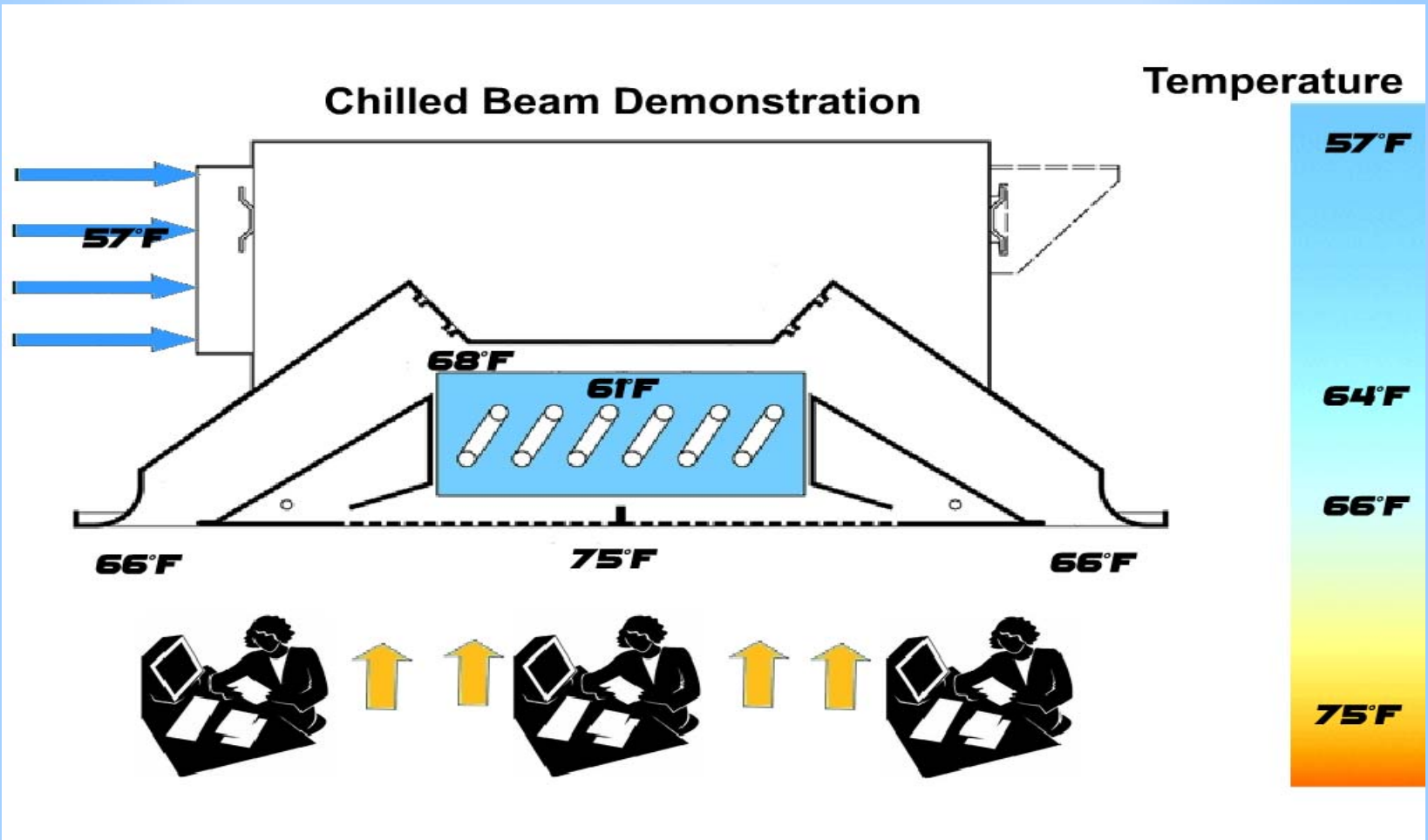
Bottom View Radiant Sail



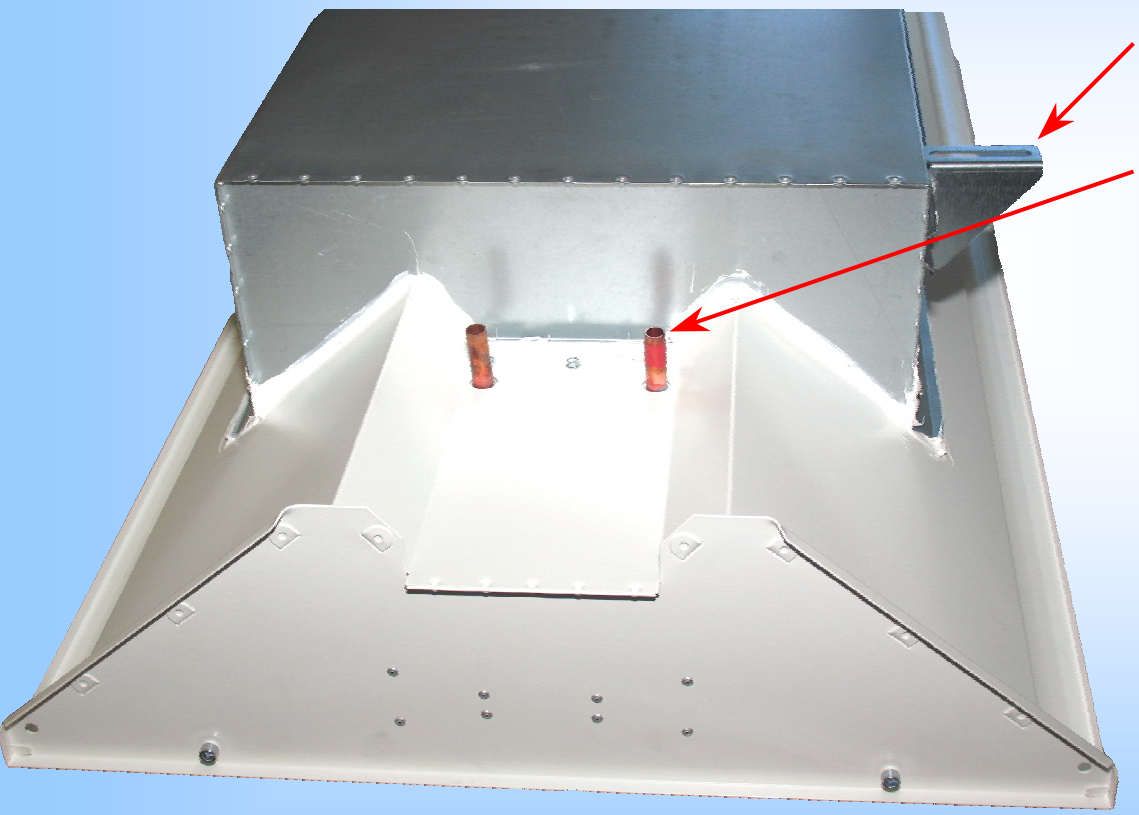
Operation


Primary 'fresh' Air
nozzles
cooled air
Room Air
Secondary Air = Cooled Room Air + Primary 'fresh' Air

Operation


Chilled Beam Demonstration
Temperature
57°F
64°F
66°F
75°F
57°F
68°F
61°F
66°F
75°F
66°F

Operation

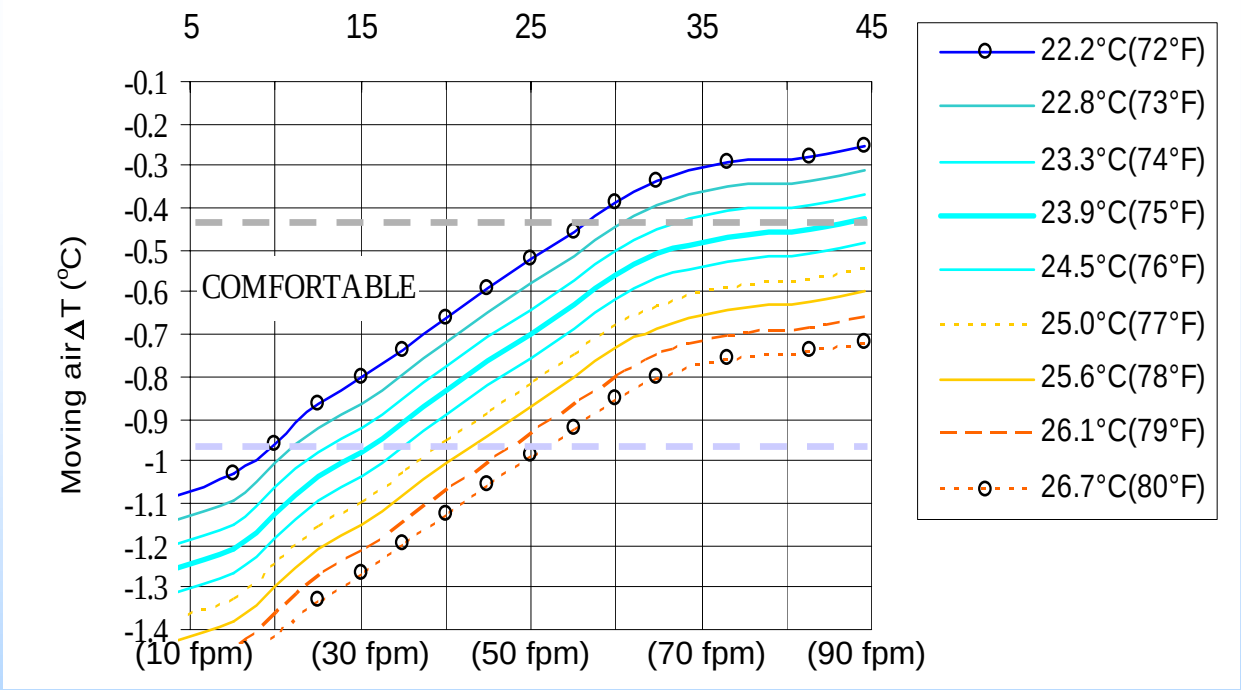


- Hanging lugs with rail for easy mounting
- 12mm (0.5”) water connections
- No moving parts
- Easy access from front, where room air enters

Operation

Twa Panel Systems, Inc.

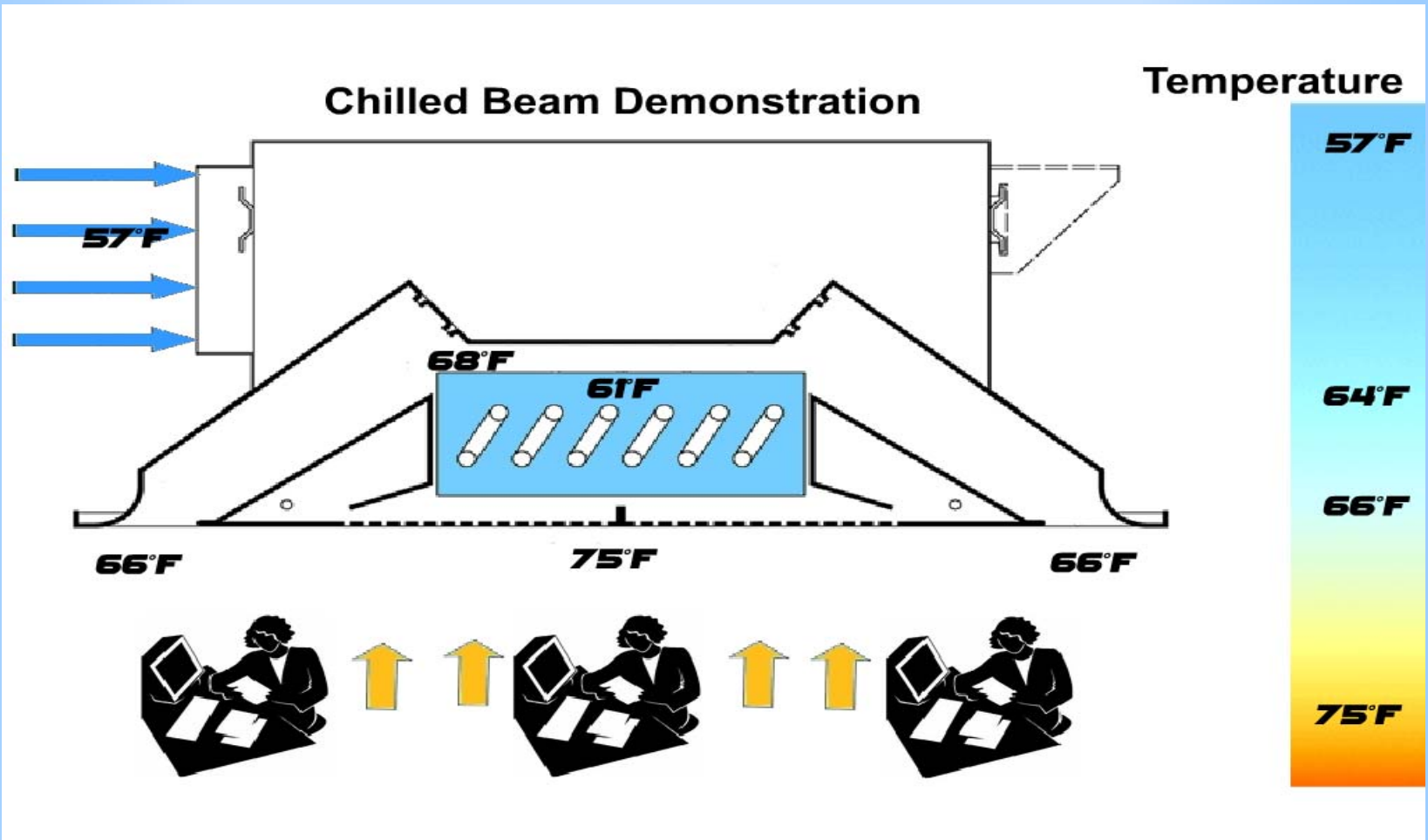
Air Distribution Chart



24.5 °C (76.0 °F) Room temperature, at <0.5 C (.9 F)ΔT allows 80 fpm room air velocity
23.9 ° C (75.0 °F) Room temperature, at <0.45 C (.8 F)ΔT allows 65 fpm room air velocity
Typical diffuser comfort line @ 0.9C (1.6 F) ΔT moving air
High performance chilled beam comfort line @ 0.45 C (.8 F) ΔT moving air

Twa Panel Systems, Inc.

Operation


Chilled Beam Demonstration
Temperature
57°F
64°F
66°F
75°F
57°F
68°F
61°F
66°F
75°F
66°F

Active Chilled Beam Capacity

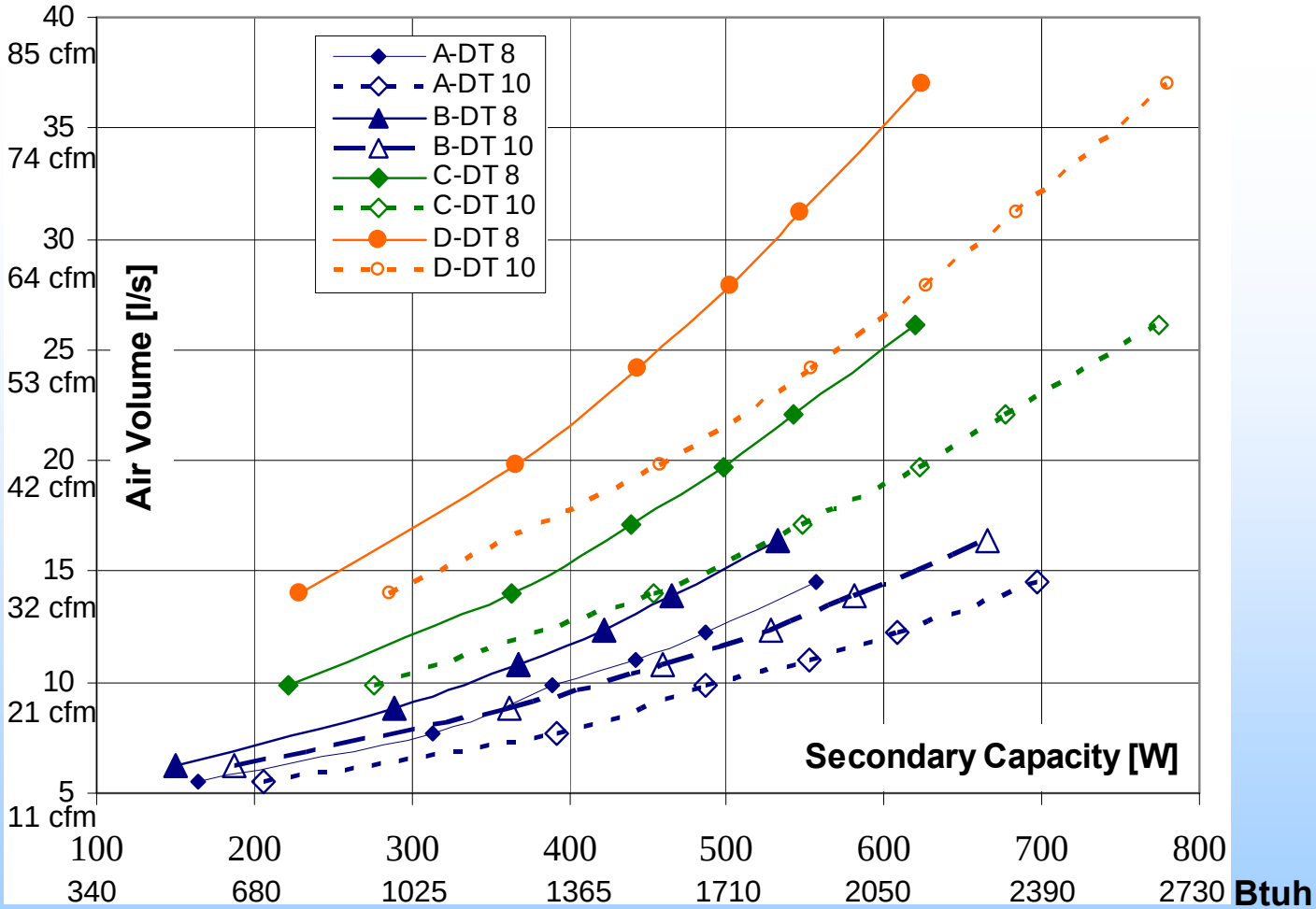
100 CFM per 1 ton of cooling

(A nozzles)

225 CFM per 1 ton of cooling

(B nozzles)

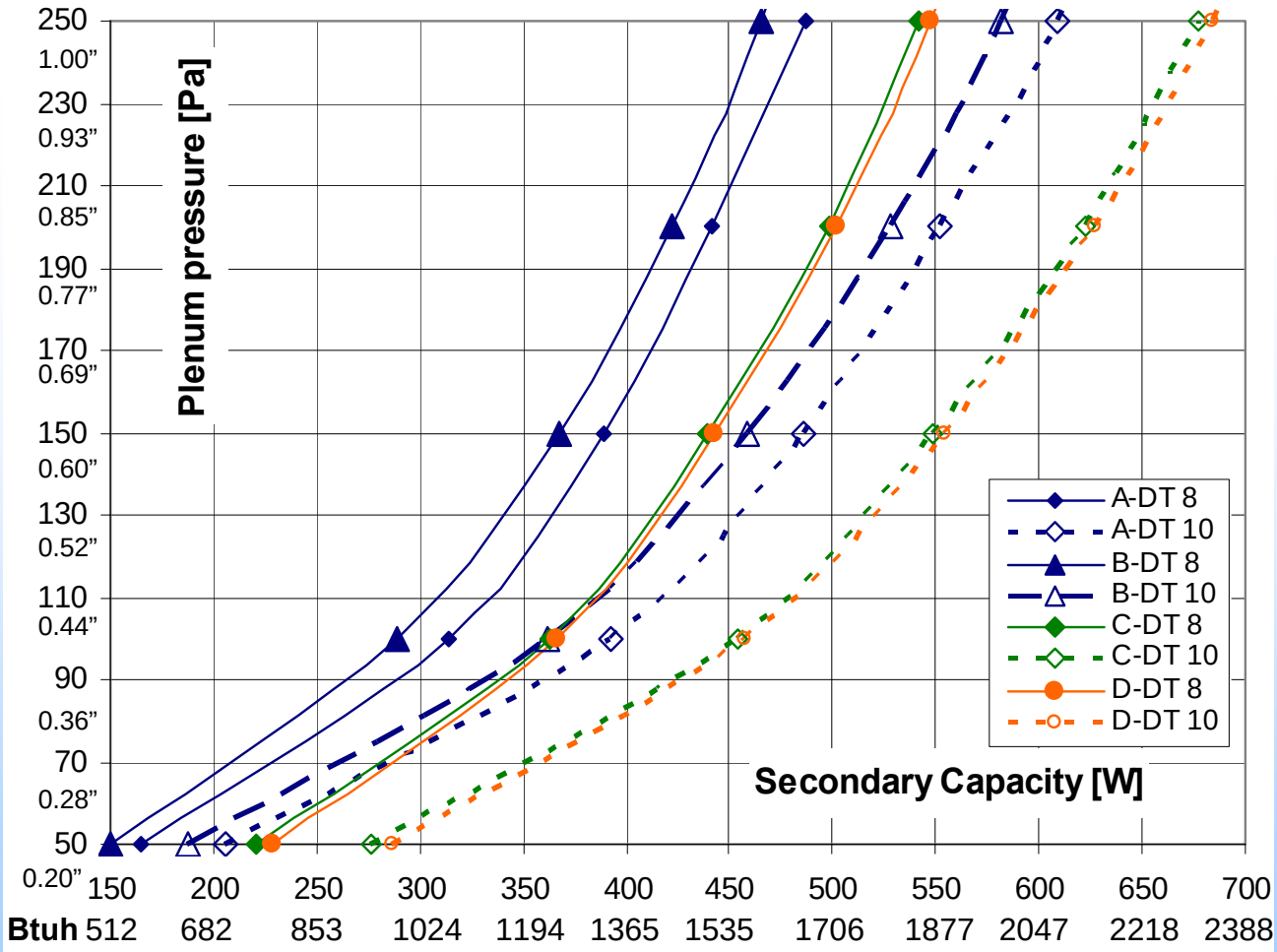
Chilled Beam Capacity vs. Primary Air Volume



Values for a 600mm x 1200mm (2'x4') Beam

Twa Panel Systems, Inc.

Chilled Beam Capacity vs. Primary Air Volume



Values for a 600mm x 1200mm (2’x4’) Beam

Twa Panel Systems, Inc.

Installation & Operation

Installation & Operation

Installation & Operation

Avenal, CA - Child Care Facility

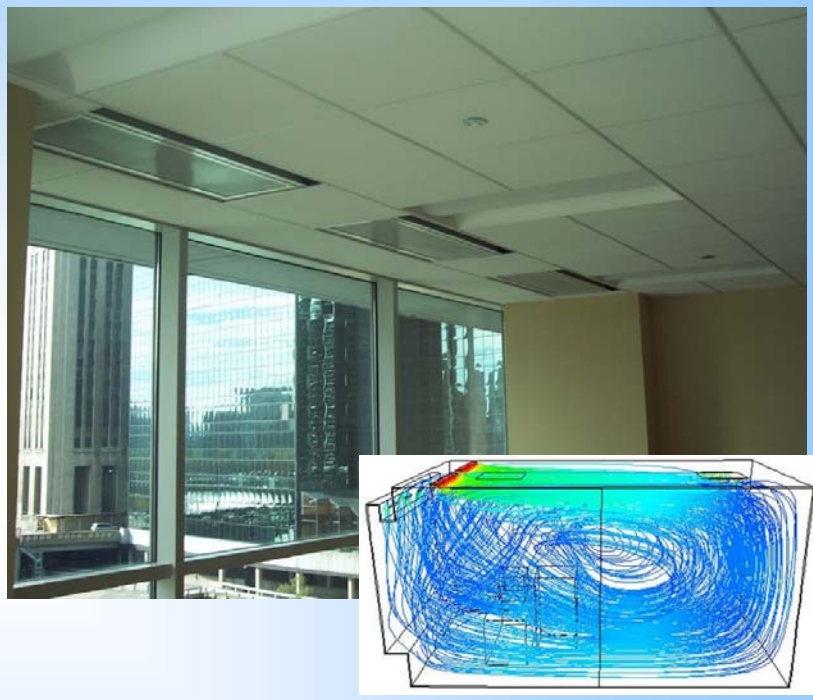
Avenal, CA - Child Care Facility

Project information

A new 12,000 square-foot quality preschool center for 80 children in the City of Avenal, California.

Avenal, CA - Child Care Facility

Chicago, IL - Multi-tenant 15 story office tower



Multi-tenant 15 story office tower retail space on the first floor. The first and top floors had dedicated HVAC systems separate from the system serving the 2nd through 14th floors.

Constitution Center Washington DC

Incline Village, CA – Center for Environmental Sciences

Incline Village, CA – Center for Environmental Sciences

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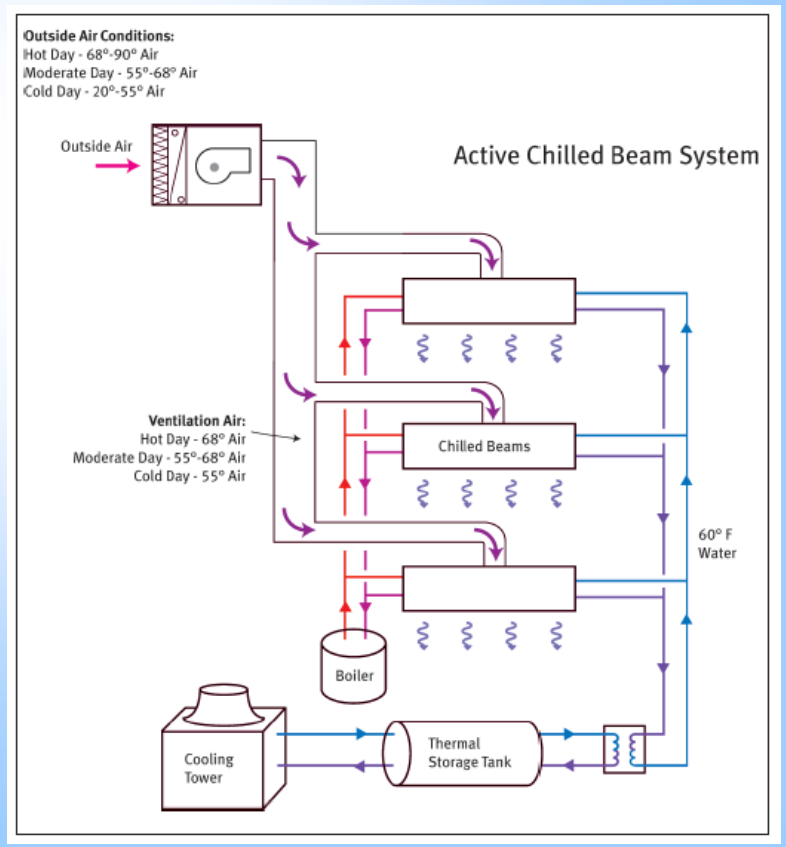
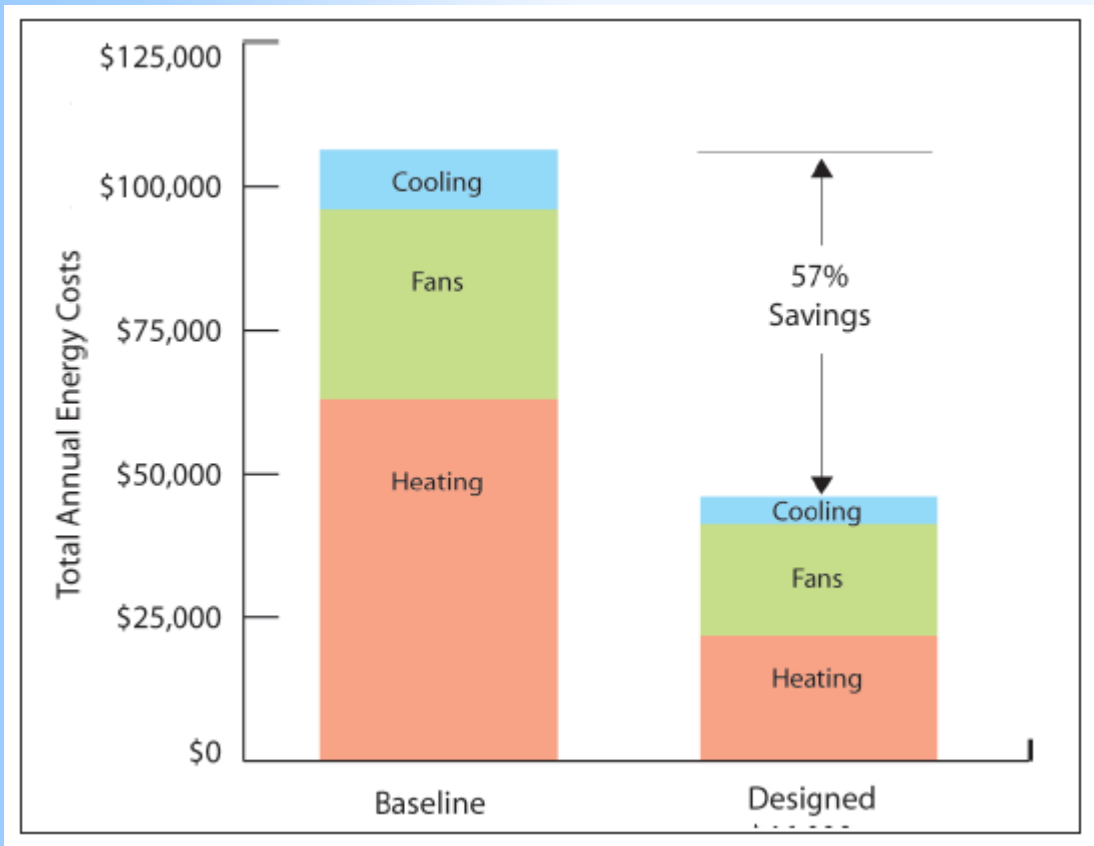
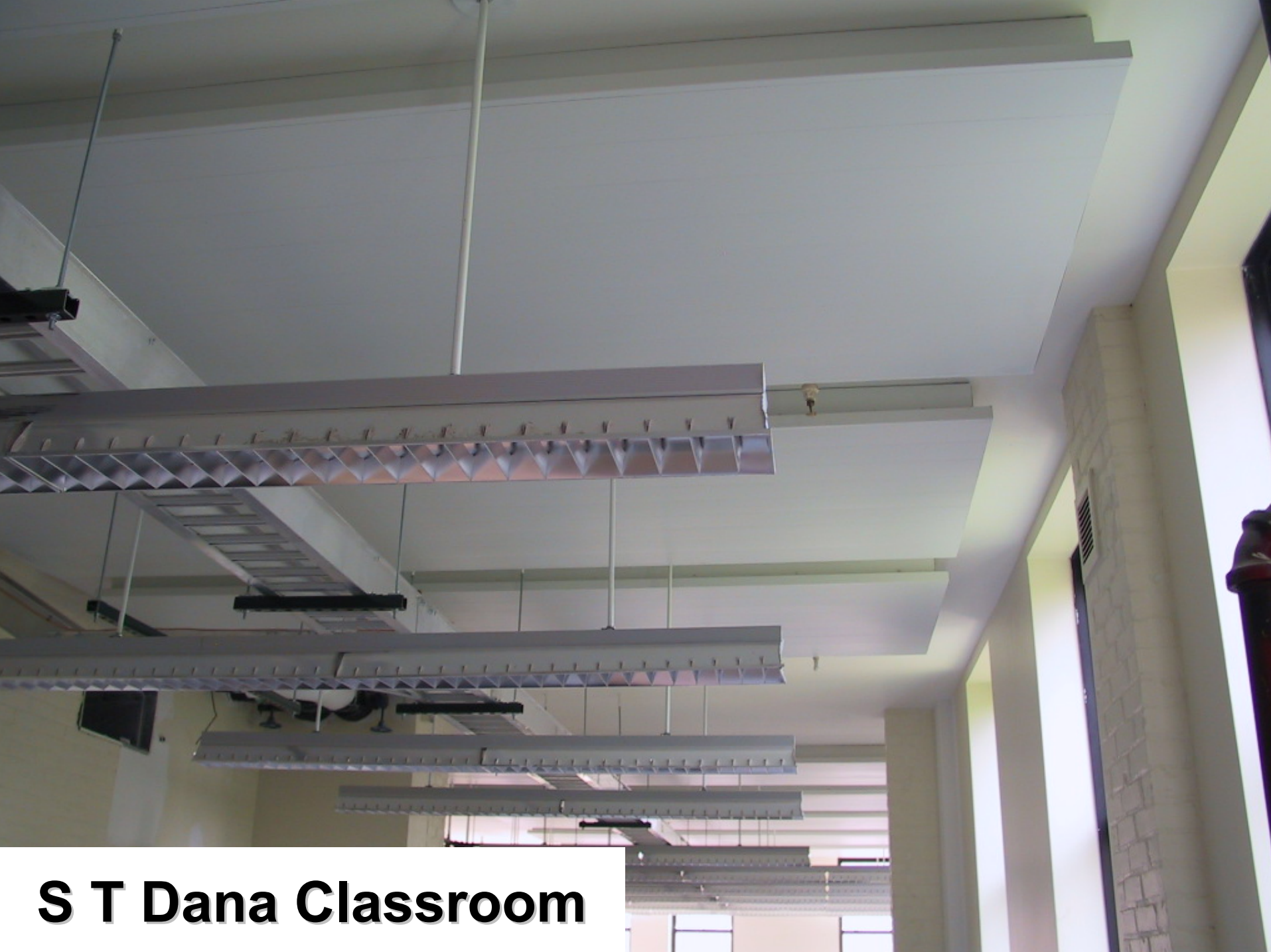


Incline Village, CA – Center for Environmental Sciences



Energy Savings



S T Dana Classroom

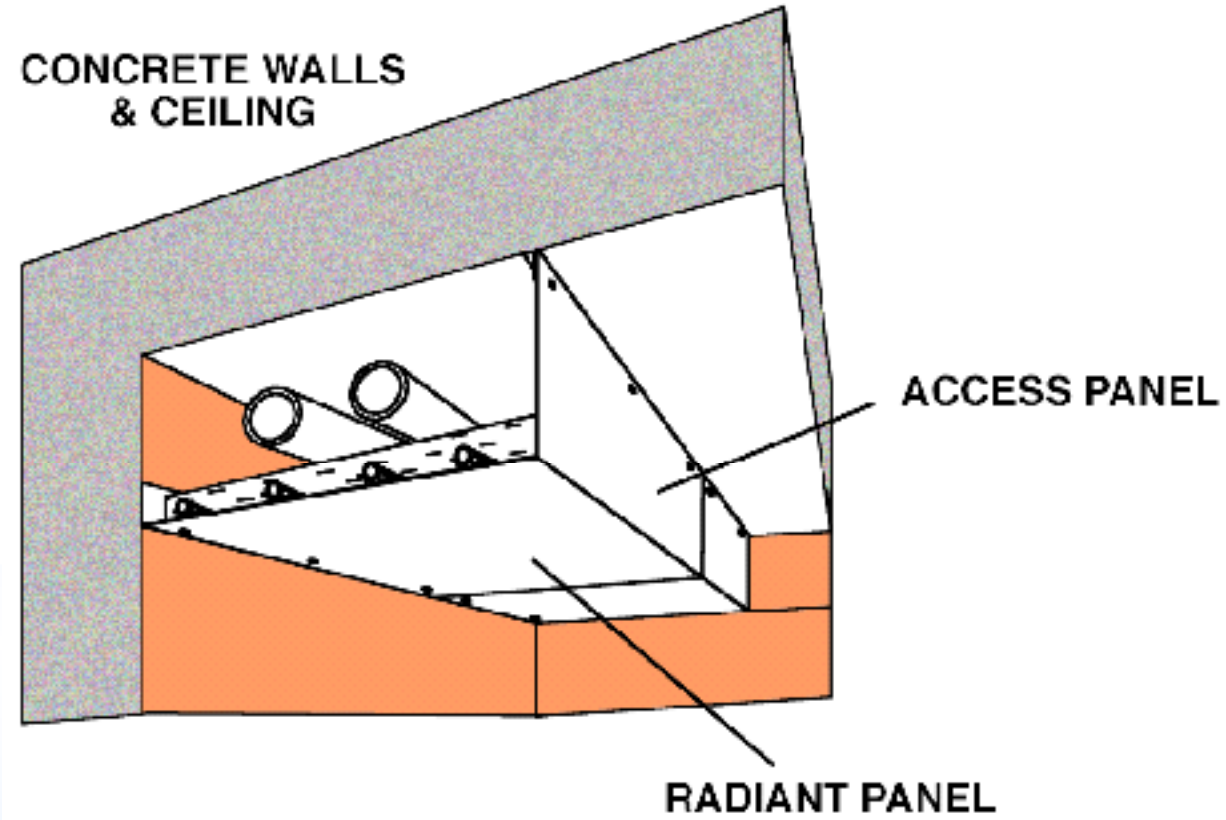
S T Dana Classroom


Free Hanging Panels

Wall Mounted Panels


Read & Discover ...together
Today's reader, tomorrow's leader

Denver Children's Hosp



Security Radiant Panels

UC SANTA BARBARA NANOTECT LAB

Total Ceiling Systems

Advantages

- Easy to use in retro fits with low ceiling heights
- Higher operating temperatures - more efficient chiller
- Hydronics uses much less energy to deliver comfort
- Loads can be treated directly
- Noise is minimized, comfort maximized

Advantages

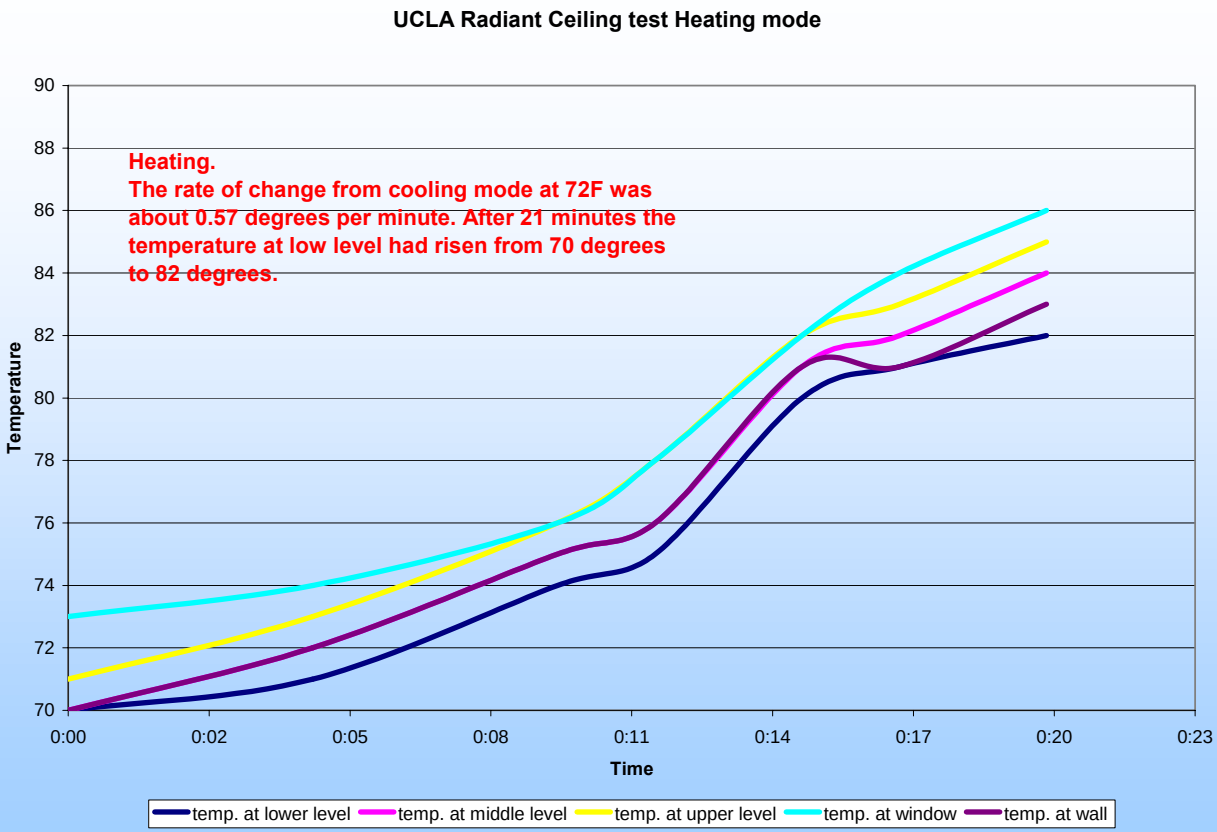
- Minimizes drafts
- Saves wall space
- Larger surface area at warmer or cooler temperature - more comfortable
- Clean
- Better air quality
- Fast response time

Advantages cont'd.

- **Quick response times**
  - **Panels are light weight and have a relatively short response time (3 to 5 minutes).**
  - **Spaces may be zoned - comfort/reduced energy consumption.**
  - **In cooling projects operable windows - no problem**

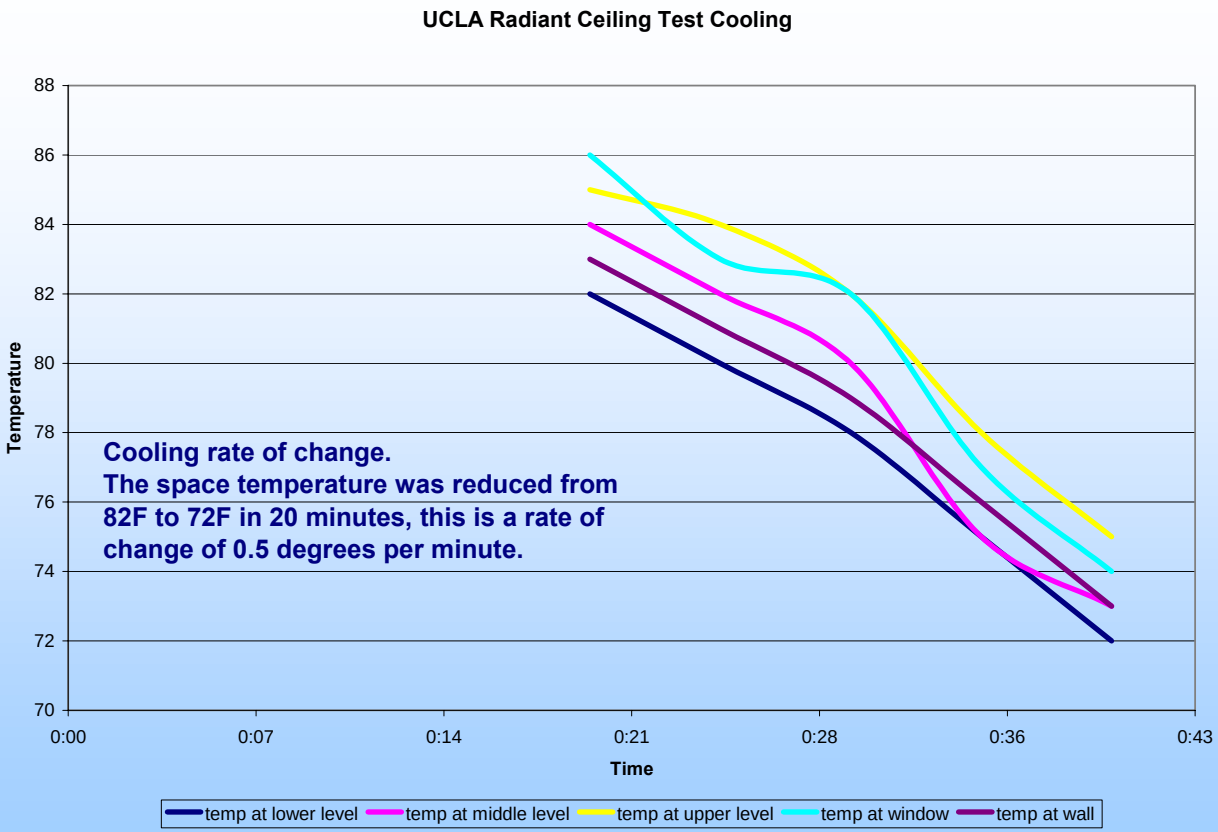
Heat Up Response

IBE Consulting Engineers Report



Cool Down

IBE Consulting Engineers Report



Advantages cont'd.

- **Supply air quantities need not exceed those required for ventilation and dehumidification.**
  - **Air only supplies required makeup fresh air, reducing air to approx. 17 – 20 cfm/person**
  - **Panels remove sensible load only**
  - **Ventilation system handles moisture load/air quality and some of sensible load as available.**
  - **Drafts are minimized.**
  - **Reduce air exchanges.**
  - **100% outdoor air – better Indoor Air Quality (IAQ) instead of recirculated (80 to 90%) air.**

Incremental Costs

- Deductions
  - Floor to floor height reduction
    - Structure
  - Ductwork Reduction
  - AHU Reduction
  - Lower maintenance cost
  - Architectural Ceilings
- Priced correctly and taking full advantage of all system reductions can lead to equivalent cost.
- Additions
  - Increased installation costs
  - Increased piping
- Panels typically bid at $20-25/sqft installed depending on finish & size of panel. Can get as low as $18/sqft.

Westminster Rose Center

Annual Energy Savings: 235 kWh, $27,800 vs. T-24

Annual Energy Use, Cost & Savings Per Square Foot							
Scheme	**T-24**	**Annual Electricity Usage (kWh)**	**Annual Electricity per Sq. Ft. (kWh/sf-yr)**	**Annual Natural Gas Usage (Therms)**	**Annual Energy Cost ($)**	**Annual Energy Cost per Sq. Ft. ($/SF)**	**Annual Energy Cost Savings ($)**
Package Units	**15.10**	**490,589**	**18.02**	**4,974**	**$80,904**	**$2.97**	**$0**
Radiant	**45.2**	**354,842**	**13.97**	**1,763**	**$59,994**	**$2.36**	**$20,910**

Cooper Union

Overhead VAV lab +Fan Coils	
Radiant ceiling with VAV lab +Fan Coil	3,676,279

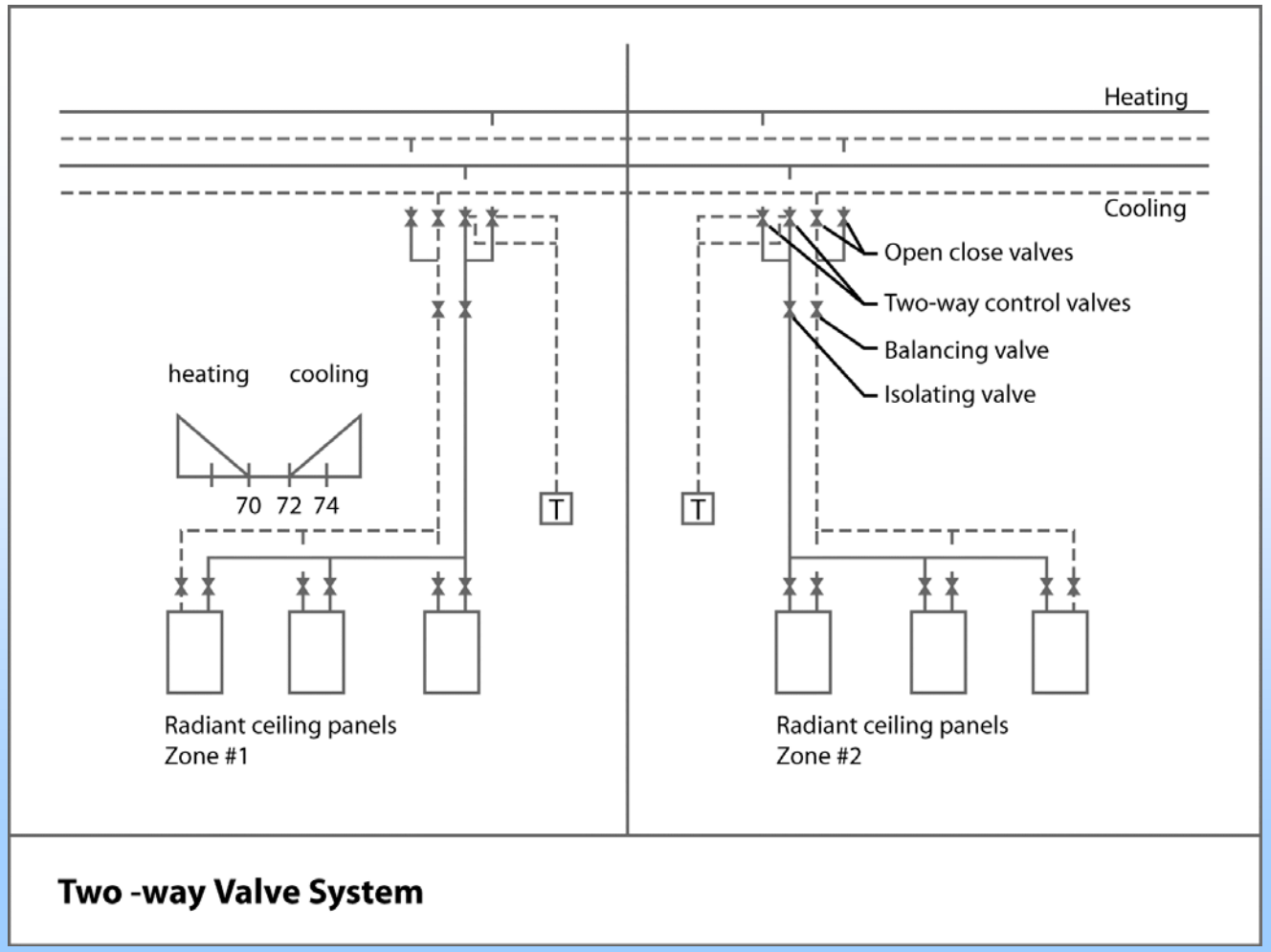
10.5%

$220,000/year utility savings

East Valley High School

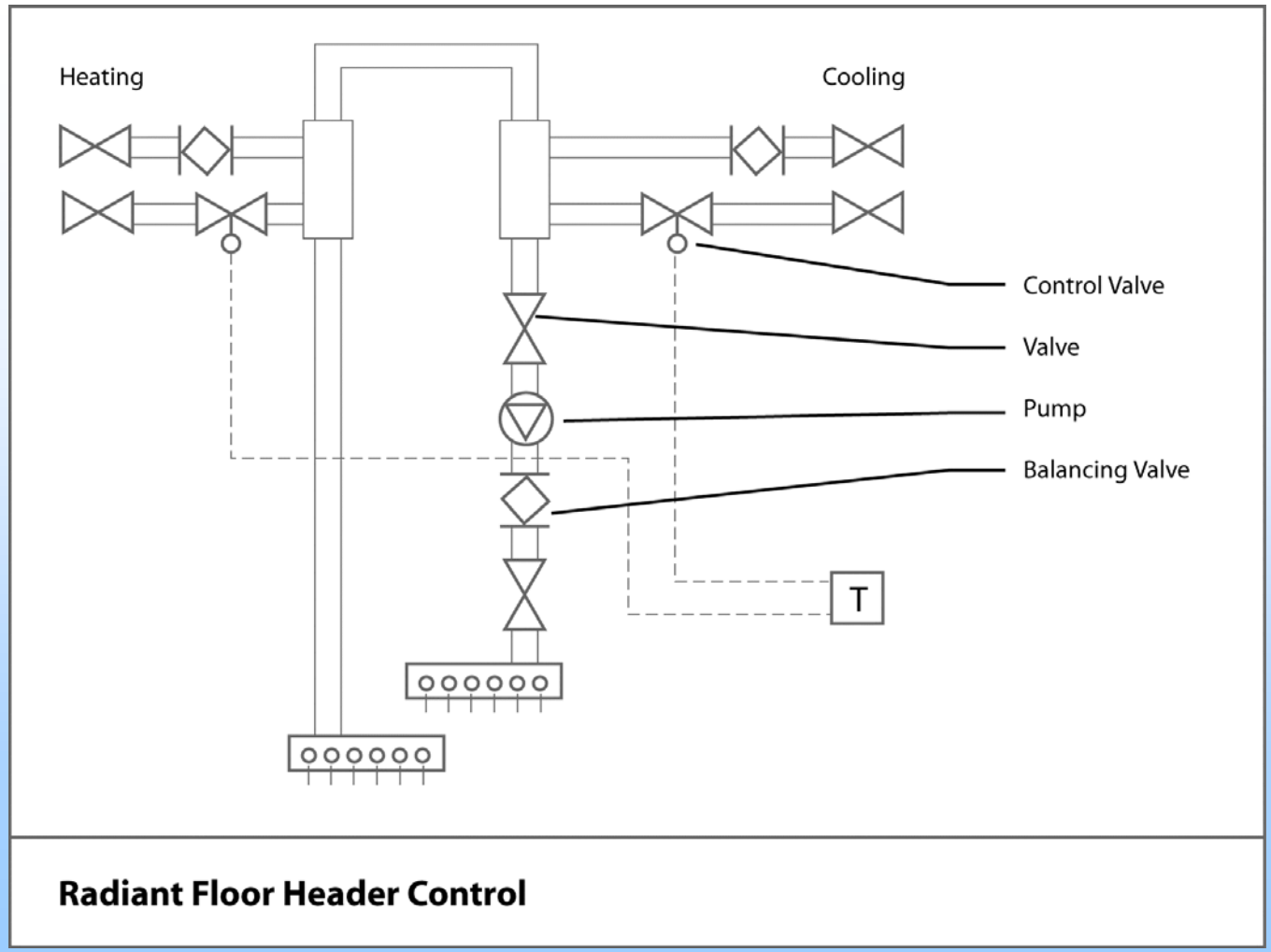
- Displacement & VAV + Radiant Panels
- Overall Campus Compliance – 33.1%
- 1,054.8 kWh Annual Energy Savings vs. T-24 2001
- $211,000 Annual Electrical Utility Cost Savings
- Priced at $280,000 premium compared to Overhead VAV when all cost savings considered: architectural, structural and HVAC.
  - Payback period slightly more than one year

Radiant Controls - Example



Two -way Valve System

Radiant Controls - Example



Radiant Floor Header Control

Power Consumption

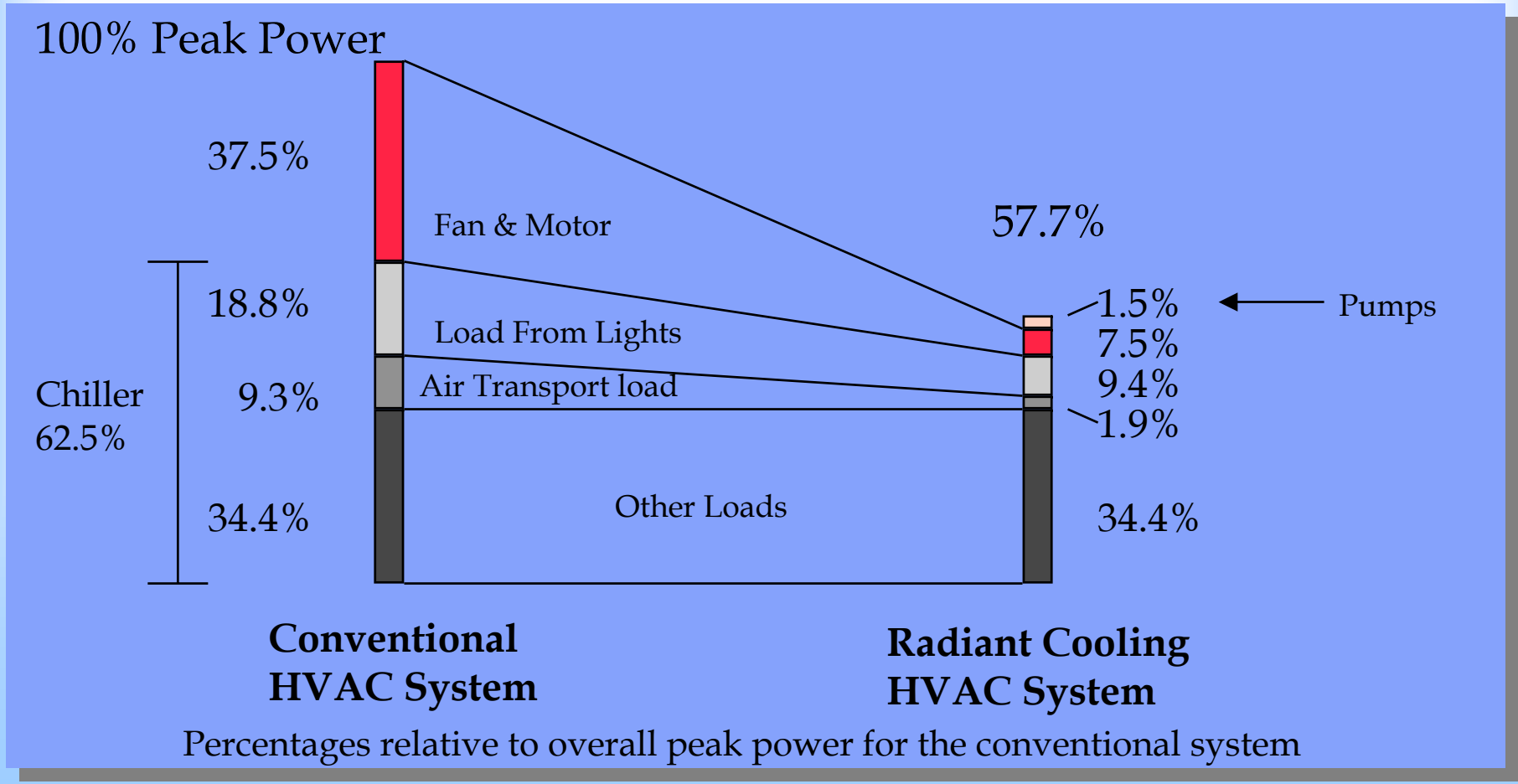


Figure from: Centre For Building Science News, Lawrence Berkeley Laboratory, "Hydronic Radiant Cooling Systems", Fall 1994.

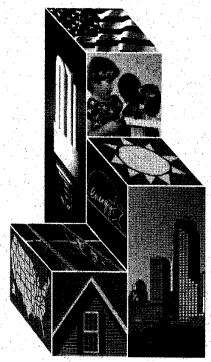
Energy Consumption Characteristics of Commercial Building HVAC Systems Volume III: Energy Savings Potential

Final Report

Prepared by
TIAX LLC

for

U.S. Department of Energy



OFFICE OF

BUILDING TECHNOLOGY

STATE AND COMMUNITY PROGRAMS

July 2002

Table 4-1: Energy Savings Potential Summary for 15 Options

Technology Option	Technology Status	Technical Energy Savings Potential (quads)
Adaptive/Fuzzy Logic Controls	New	0.23
Dedicated Outdoor Air Systems	Current	0.45
Displacement Ventilation	Current	0.20
Electronically Commutated Permanent Magnet Motors	Current	0.15
Enthalpy/Energy Recovery Heat Exchangers for Ventilation	Current	0.55
Heat Pumps for Cold Climates (Zero-Degree Heat Pump)	Advanced	0.1
Improved Duct Sealing	Current/New	0.23
Liquid Desiccant Air Conditioners	Advanced	0.2 / 0.06[12]
Microenvironments / Occupancy-Based Control	Current	0.07
Microchannel Heat Exchanger	New	0.11
Novel Cool Storage	Current	0.2 / 0.03[13]
Radiant Ceiling Cooling / Chilled Beam	Current	0.6
Smaller Centrifugal Compressors	Advanced	0.15
System/Component Diagnostics	New	0.45
Variable Refrigerant Volume/Flow	Current	0.3

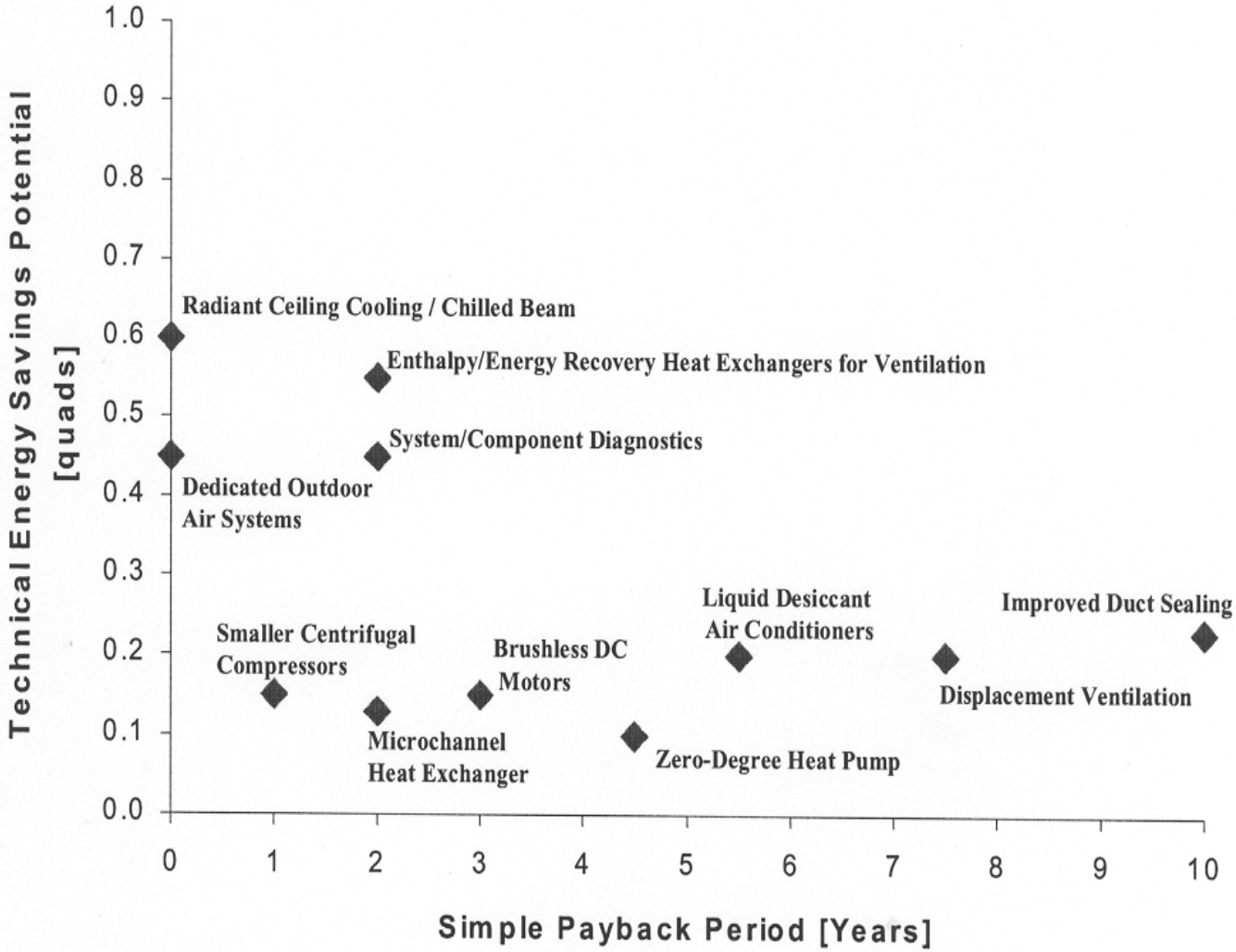


Figure 5-2: Estimated Technical Energy Savings Potential and Simple Payback Periods for the 15 Options

Table 4-37: Summary of Radiant Ceiling Cooling Characteristics

Characteristic	Result	Comments
Technical Maturity	Current	Much more common in Europe than in the U.S.
Systems Impacted by Technology	All HVAC systems	
Readily Retrofit into Existing Equipment/Buildings?	No	Requires installation of large ceiling panels and piping throughout building.
Relevant Primary Energy Consumption (quads)	3.4 Quads	All non-individual cooling and ventilation energy, heating energy tied to OA
Technical Energy Savings Potential (quads)	0.6 Quads[64]	• 17% cooling energy reduction • 10% heating energy reduction (all from DOAS) • 25% ventilation energy reduction
Approximate Simple Payback Period	Potentially immediate	In new construction or major renovation
Non-Energy Benefits	Improved occupant comfort, low noise, low maintenance	Radiant heating/cooling generally considered more comfortable than forced-air methods. Low maintenance (assuming humidity issue properly managed). Less noise from air distribution. According to Stetiu (1997), radiant cooling reduces ventilation, which reduces space needed for ducts by up to 75%. Zoning readily implemented.
Notable Developers/Manufacturers of Technology	Frenger (Germany). Trox (Germany). Dadanco (Australia; Active Chilled Beams; uses smaller fans to distribute primary air through unit, in combination with secondary, room air)	
Peak Demand Reduction	Yes	Decreases the peak ventilation load required to deliver peak cooling. Stetiu (1997) found 27% demand reduction on average (throughout U.S.).
Most Promising Applications	Tight buildings with high sensible cooling loads, located in low-humidity cooling climates (e.g., hospitals due to one-pass ventilation requirement). Not buildings with appreciable internal moisture loads (e.g., health/fitness clubs, pools).	
Technology "Next Steps"	HVAC system designer/installer education with approach; integration into commonly-used HVAC design tools; demonstration of operational benefits. Cost comparison with VAV system using an enthalpy wheel and dedicated outdoor air systems. Energy savings of chilled beam versus VAV.	

LEED Green Build

Rating system which has 6 major catagories

- Sustainable Sites
- Water efficiency
- Energy and Atmosphere
- Material and Resources
- Indoor Environmental Quality
- LEED Innovation Credits

Possible LEED Points

- Water use – enthalpy wheel of DOAS
- Energy – DOAS and radiant panel reduces energy 25-35%, chiller without HCFC's
- Materials – radiant panels 100% recyclable and easily can contain recycles
- IEQ – increased ventilation effectiveness, thermal comfort, controllability of system
- Innovation credit – decoupling sensible and latent loads
- Fast response time allows use of operable windows

Installation Cost Comparison
3 kW (1 ton) Nominal

Operational Savings with Beams:

- 50% electric power for the chiller with 16ºC (61ºF) water, or ground water, for cooling
- Reduced Primary air with VAV
- Tight temperature control where required, with VAV
- No secondary fan power
- No moving parts to maintain
- No filters to change

Installation & Operation

Installation

- Easy mounting with hanging rail and lugs
- No moving parts
- Easy access from the front
- No electrical connections
- No controls

Operation

- High chilled water temperature 14-16°C (57-61°F)
- Primary ‘fresh’ air quantity tailored to suit.
- Self regulating
- VAV for tight temperature control

Installation & Operation

Installation & Operation

Installation & Operation

Installation & Operation

Conclusions

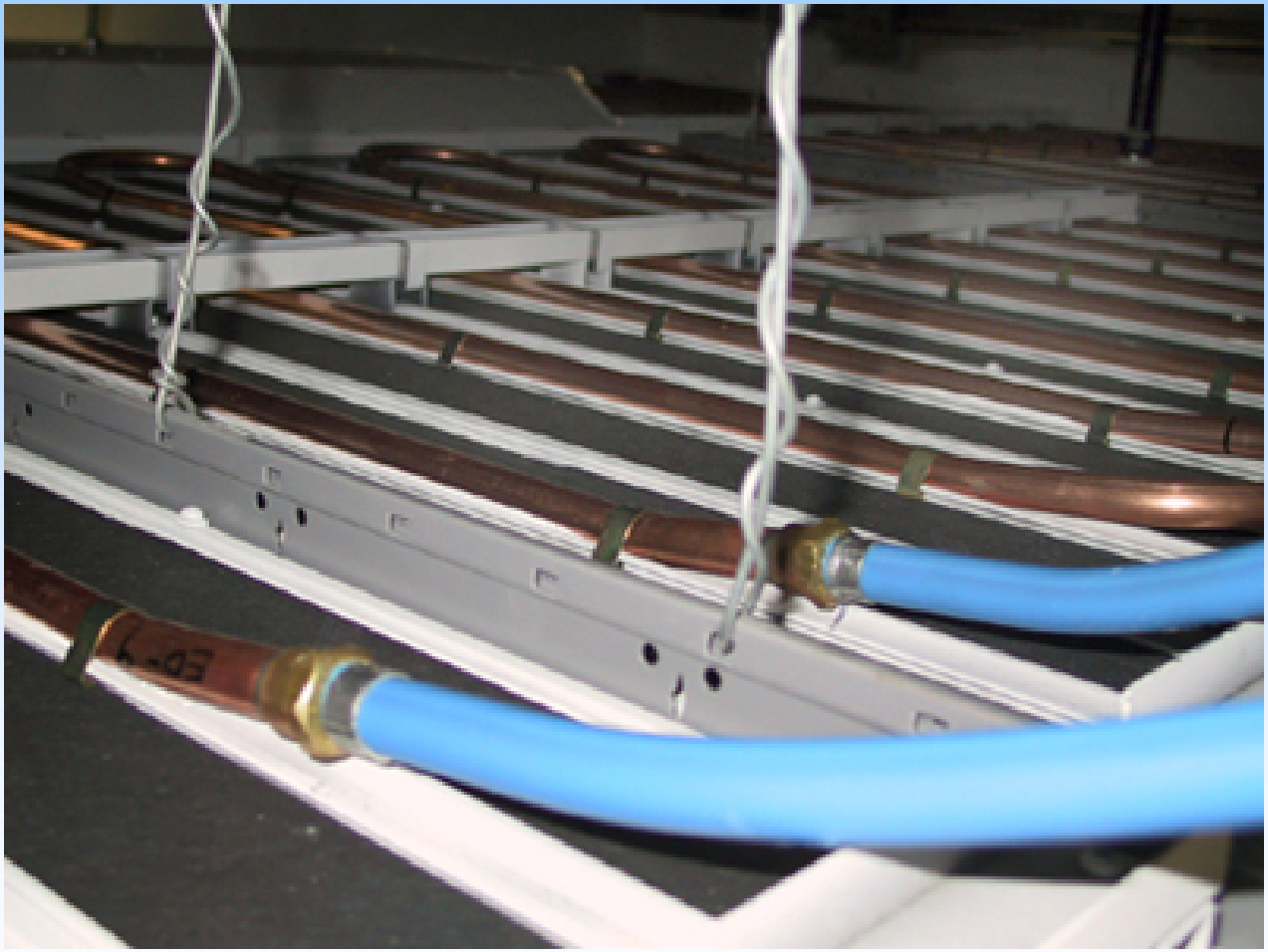
- Chilled beams are the ultimate low energy, low noise air conditioning solution.
- High standards of indoor climate can be achieved with excellent air distribution and control.
- Highly variable loads can be addressed using VAV on the Primary air supply.
- Simple commissioning or both air and water.
- No maintenance.

Installations -Radiant Panels



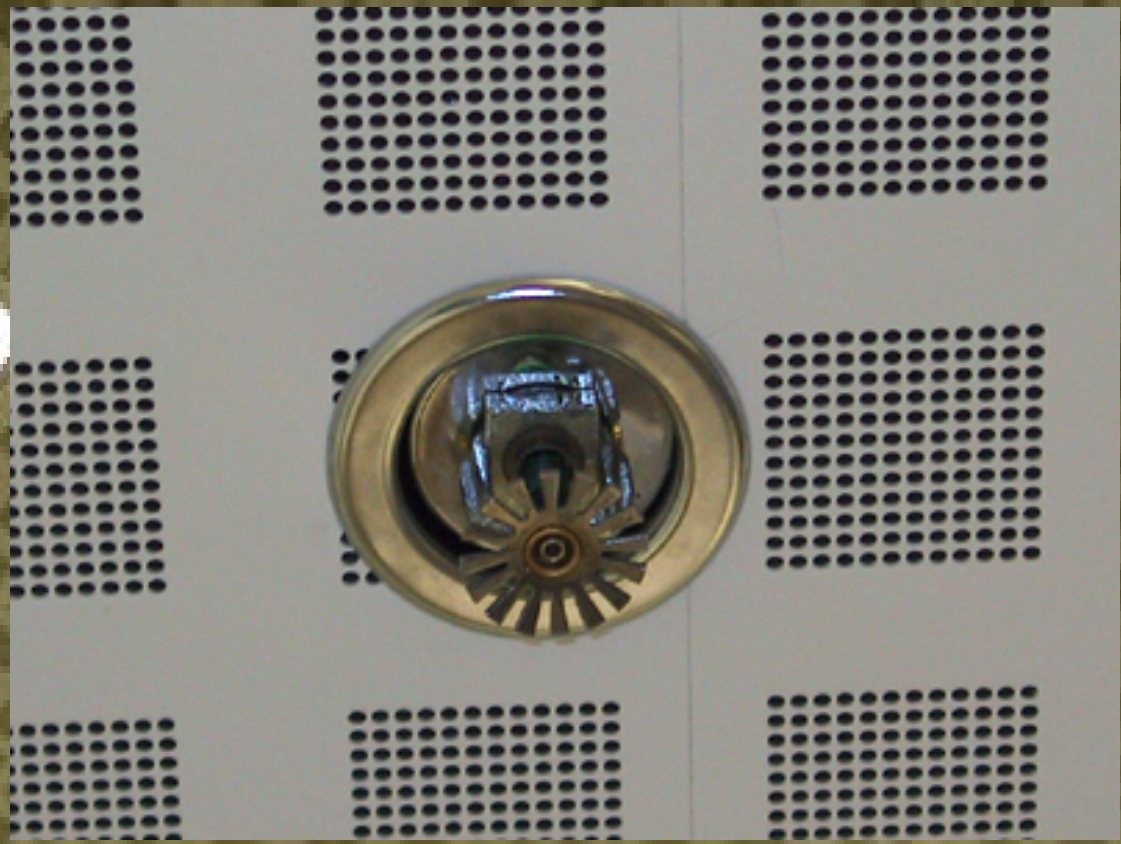



Connections



Tubing or Pipe

Crimping



Twa
Panel Systems, inc.

Thank-you.

- www.twapanels.ca
- www.doas-radiant.psu.edu
- www.eere.energy.gov/buildings/info/publications.html

  Report title:Energy Consumption Characteristics of Commercial Building HVAC Systems: Volume III, Energy Savings Potential